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Assessing the Impact of the 2008-09 Global Economic Crisis on the Structure and Dynamics of the Global Trade System: A Network Analysis of International Trade

DISSERTATION

submitted in partial satisfaction of the requirements
for the degree of

DOCTOR OF PHILOSOPHY

in Sociology

by

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DEDICATION

To

Gilivelia and Ricardo Jacinto

in recognition of their worth

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

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Jacinto, Martín. "Assessing the Interplay Between the Structure of the Global Trade Network and National Economic Productivity During the 2008-09 Global Economic Crisis."

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ABSTRACT OF THE DISSERTATION

Assessing the Impact of the 2008-09 Global Economic Crisis on the Structure and Dynamics of the Global Trade System: A Network Analysis of International Trade

by

Martín Jacinto

Doctor of Philosophy in Sociology

University of California, Irvine, 2022

Professor Katherine Faust, Chair

Currently, the world economy is experiencing a global trade crisis. Specifically, the Covid-19 pandemic has disrupted the operation of complex global trade networks that has led to a severe decline in global economic growth. This severe decline in global economic growth is bound to compound inequalities between and within nation-states. Yet little is still known about how the global trade network and its structural inequalities adapt and respond to the impact of a global economic crisis. This dissertation investigates the impact of the 2008-09 global economic crisis on the structure and dynamics of the global trade network. It addresses three questions central to sociological research on globalization and economic development: 1) *How did the global trade network adapt and respond to the 2008-09 global economic crisis?* 2) *In what ways did the 2008-09 crisis affect economic inequalities between nation-states?* 3) *And, how did the 2008-09 crisis affect the dynamic interplay between the macro-level structure of the global trade network and economic productivity of nation-states?* To address these questions, I situate my study within social network analysis and economic sociology to advance a large-scale and longitudinal quantitative study of the aggregate global trade network throughout the period of the

2008-09 global economic crisis. Exploring the effect of a global economic crisis on the structure and dynamics of the global trade network advances the discipline by providing a unique analytical foundation in which to study the impact of contemporary global economic crises on structural inequalities at the macro- and micro-level of the world economy. To achieve this end, I collected and constructed one of the largest data sets of international trade networks from data provided by the International Monetary Fund's *Direction-of-Trade Statistics,* as well as econometric data from the World Bank's *Development Indicators* database. Findings from this study illuminate three patterns related to globalization during the period of the 2008-09 global economic crisis. First, despite the devastating impact of the 2008-09 crisis on international trade, economic globalization continued to expand after the crisis, albeit not as high as in the pre-crisis era. Second, the global trade network not only conforms to a hierarchical core-periphery structure, but this structure was also robust to the impact of the 2008-09 crisis. Third, the presence of this structure was a significant predictor of national economic productivity after the 2008-09 crisis. Thus, the findings demonstrate that the expansion of globalization through international trade appeared undeterred by the crisis, and this expansion has facilitated the formation and stability of structural inequalities across the global trade network. These inequalities played a significant role in generating national economic productivity after the 2008-09 crisis.

INTRODUCTION

In the aftermath of the 2008-2009 global economic crisis, empirical trends in global trade between regions commonly associated with the Global South (Latin America, Africa, Southeast Asia, and the Middle East) and domestic economic turmoil in the Industrial West motivated a mainstream narrative amongst economists known as the "Rise of the Global South". Some social scientists furthered the narrative by claiming that the crisis accelerated a global rebalance where the gravity of global production and trade has shifted from major global North economies (US, Western Europe, and Japan) to the South ones, and is associated with a global convergence[1] where the performance gap between the two zones has narrowed (Breslin 2011; Kiely 2015; O'Neill 2001; Pieterse 2011). Trends in trade and production prompted the World Bank (2011) to declare that the global economy is undergoing a shift toward multipolarity. Others contend that these claims are exaggerated and overlook the multiple levels of inequality pervasive within globalized networks of production chains, firms, countries, and regions that is associated with variable economic development and sustain global dependency on the North (Carmody and Murphy 2017; Saad Filho 2014). The "Rise of the Global South" narrative fails to capture the diversity of circumstances, domestic policies and global constraints that accounted for the variable rate of economic growth following the crisis.

To answer these research questions, I drew upon a political economy framework that illustrates the global economy as comprised of dynamic networks of international trade that are themselves defined by structural inequalities at various levels of production chains, firms, and economic policy. I then analyzed international trade data from 2000-2017 using a social network

1 The concept of convergence (or the catch-up effect) is widely used in economics, and it refers to the hypothesis that global South countries outpace that of northern ones and thereby converge in living standards (Sachs 1995).

analysis approach. Findings from this study show that the "Rise of the South" narrative overlooked the global networked forms of economic organization that relate to the developmental trajectories of countries. As such, I demonstrate that the trends during the crisis were not idiosyncratic nor portending a widespread global rebalance, but that the extraordinary performance of certain South countries was a function of a latent global structure that perpetually reinforces structural inequalities at the macro-level of the world economy. Furthermore, this study contributes to the literature of development by revealing how certain Global South experienced substantive development during one of the largest economic downturns in modern history and address mechanisms within these global economic networks that impeded growth for most of the Global South.

BACKGROUND

Crises in Previous Eras

Literature on the new international division of labor (NIDL) link the surge in manufactured and primary exports from the non-core countries to the establishment of labor-intensive export platforms set up by multinational firms in the global South in the wake of economic crises in the second half of the 20th century (Fröbel et al. 1981; Robinson 2004, 2008). Following world economic crises in the 1970s, Global South countries implemented massive trade liberalization reforms that promoted export-led economic growth strategies that were experiencing national economic stagnation. The Reagan and Thatcher administrations in the US and UK, respectively, bolstered the spread of neoliberalism that made export-oriented growth the prevailing orthodoxy for global South countries throughout the world. Neo-liberalism was a broad series of political and economic policies aimed at reconfiguring national and integrating new economies into the world economy through increased international trade. Neoliberal policies were lauded for giving small

and developing economies in the South the opportunity to benefit from scale economies and to learn from exporting to much larger trade partners, and less inclined to trade with other South countries. Over the period, the outsourcing and offshoring of production to growing economies further globalized circuits of production and interlinked economies into networks of bilateral trade and production. Since then, exports as a share of low- and middle-income countries' GDP grew from about 10 percent in 1970 to 30 percent in 2007 (Milberg and Winkler 2009).

Furthermore, the growth of export industries in the Global South are linked to both the growing demand in northern markets and demand for intermediate products used for finished products in the Global North. This is clearly visible in changes in the share of Global South countries in world output but much less so in levels of per capita income relative to Global North countries (Malike 2013). However, the distribution of rewards from export-led development varies across regional zones of the world economy. For example, during the 1980s, Southeast Asian economies were attractive outlets for multinational firms to establish production sites, but most Latin American countries became heavily dependent on the exportation of agricultural commodities and natural resources in the wake of their economic crises (Robinson, 2008). Throughout this period, Latin America became the region with the slowest growth compared to other South regions and behind the world. The impressive success achieved by East Asian newly industrializing economies—Taiwan, South Korea, Singapore, and Hong-Kong—since the 1960s has led scholars to evaluate why other regions failed to grow at similar rates. Furthermore, crises in the past have been followed by organizational and structural changes within nation-states that often lead to accelerated growth.

Since the mid-1980s, the proliferation of export-oriented industries within the South has led to both increased economic growth and growing global interdependence within the South

between smaller and larger economies. Between 1980 and 2011, South-South trade as a share of world merchandise trade rose from 8.1 percent to 26.7 percent while the share of North-North trade declined from about 46% to less than 30% (Malik, 2013). Certain scholars perceive the emergence of BRIC countries (Brazil, Russia, India, and China) and the structural weaknesses experienced by northern economies from the 2008-2009 crisis signal profound shifts in the world economy. Pieterse (2011) defines the post-crisis era as "the rise of the South" and an "East-West turn" where the supremacy of the west has eroded, and the South has grown increasingly independent from the North. Along these lines, large BRIC economies gained power during the period of the crisis by serving as alternative destinations for low-valued exports from smaller South economies (Kaplinsky and Farooki 2010).

The perceived economic success of developing countries within the past decade raised debates about a "Rise of the South" where the concentration of global political and economic power of "core" North economies has decentralized, and economic trade between many "peripheral" South economies is slowly shifting the gravity of global production and trade (Breslin 2011; O'Neill 2001; O'Neil and Stupnytska 2007; Wilson and Purushothaman 2003). Against this backdrop, the 2008-2009 global economic crisis was viewed as accelerating the Global South's emergence (Bergstrem 2008; Pieterse 2011). However, the literature continues to lack empirical analyses to verify whether the crisis was indeed followed by uneven economic growth across the world economy. Thus, the aim of this dissertation aims is to empirically triangulate a link between global economic crises, trade, and development to comprehend the impact of a global economic crises on global inequality.

2008-2009 Global Economic Crisis

The collapse of the U.S. housing market in 2007 initiated a large economic downturn that quickly spread across the world economy through financial and trade channels. The scope and magnitude of the 2008-2009 global economic crisis was comparable to the great depression of the 1930s. Some scholars argue that the crisis was not simply an economic downturn, but a structural crisis that undermined the global political and economic dominance of the industrial West (Wallerstein, 2010). Others argue that the crisis accelerated two long-term trends in the global economy: "the consolidation of [Global Value Chains] and the growing salience of markets in the South" (Cattaneo, Gereffi, and Staritz 2010). Moreover, while the 2008-2009 global economic crisis is widely viewed as a financial crisis, it nevertheless elucidated the pervasive and complex globalization of production. For example, Jansen and von UexKull (2010) study on the global automotive supply chain found that throughout the period of the crisis the postponement of new auto purchases by U.S consumers affected not only the U.S automobile industry, but also the Liberian rubber sector that produces the material for the tires, and so on through the global automotive supply chains. Thus, the impact of the crisis was felt globally (rather than regionally) and affected both financial markets as well as global trade and production.

The financial crisis led to a severe decline in world economic output that exceeded recent economic downturns. The crisis largely affected the advanced economies of the West, which experienced an unprecedented 7.5% decline in real GDP during the 2008-2009 period (IMF 2009). According to the World Bank, since the Great Depression, the world's gross domestic product (GDP) dropped by 2.2 percent in 2009, with a sharp 3.3 decline in the global North and global South economies went from 5.6 percent growth in 2008 to 1.2 percent in 2009 (World Bank 2010). Regarding international trade, at its peak, world trade declined by about 12 percent in 2009, which far exceeded the estimated loss of 5.4 percent during the 2007-2008 period (WTO 2010). The

decline in world trade was linked to a 13 decline in manufacturing production and a 20 percent drop in global trade of manufactured goods (Eaton et al. 2016). As a result of the crisis, the world's largest importers—United States, European Union, and Japan—experienced negative GDP growth rates which massively disrupted South economies that are reliant on exports to these large markets (World Bank 2014). However, despite the massive interruption, merchandise trade grew to 4.4 percent by 2018, which closely matches the 4.7 percent output prior to the crisis (WTO 2018).

As rates of economic output stabilized and the world economy recovered, a key narrative that emerged within international relations and globalization studies was the role of South economies in the post-crisis recovery of the world economy. According to the United Nations, "countries of the South are collectively bolstering world economic growth, lifting other developing economies, reducing poverty and increasing wealth on a grand scale", and South-South trade was a key factor in the world economy's recovery (see Malik 2013: 1). Other studies find that greater corporate wealth in the South with the share of South firms in the global Fortune 500 having increased from 6.6% in 2000 to 30.4% in 2015 (Horner and Hulme 2017). The growing trade activity within the South is associated with a rise of a "global middle class" in the South (Guarin and Knorringa 2014) which is linked with widespread improvement in health (see Jamison et al. 2013) and education (see Dorius 2013).

Since the mid-1980s, the proliferation of export-oriented industries within the South has led to both increased economic growth and growing global interdependence within the South between smaller and larger economies. Between 1980 and 2011, South-South trade as a share of world merchandise trade rose from 8.1 percent to 26.7 percent while the share of North-North trade declined from about 46% to less than 30% (Malik 2013). Certain scholars perceive the emergence of BRIC countries (Brazil, Russia, India, and China) and the structural weaknesses

experienced by Global North economies from the 2008-2009 crisis signal profound shifts in the world economy. Pieterse (2011) defines the post-crisis era as "the rise of the South" and an "East-West turn" where the supremacy of the west has eroded, and the South has grown increasingly independent from the North. Along these lines, large BRIC economies gained power during the period of the crisis by serving as alternative destinations for low-valued exports from smaller South economies (Kaplinsky and Farooki 2010).

Others argue that these accounts confuse the economic achievements of China and India with the overall performance of developing economies and that trade patterns reflect a different phenomenon: "performance disparities within the Global South remain significant and, over the long term, most [developing economies] have underperformed significantly related to the [advanced economies]" (Saad-Filho, 2014: 595). Contrary to arguments of decoupling (Bergstrem 2008; Pieterse 2011), studies find that most Global South economies were adversely affected. The crisis affected the Global South in several ways. First, the reduced demand for manufactured exports and lowered commodity prices (Baldwin 2009). This reduction in demand then triggered steep drops in private capital inflows, a slow-down in remittances, as well as financial losses associated with domestic stock market disruptions and exchange rate volatility (Gore 2010). Also, while the share of South-South manufacturing and trade has outpaced the share of North-North trade since the 2008-2009 crisis; the uneven development across the South following the crisis created prosperity for some while other economies declined in relative and even in absolute terms and suffered significant poverty and exclusion effects (UNCTAD 2012a). By 2009, the real GDP of North economies fell by 3.5 percent while real GDP of South economies grew by 1.9 percent (UNCTAD 2012b). However, these numbers obscure variation in economic growth across the South when considering the performances of China and India. When these countries are excluded,

real GDP of South economies was estimated to have declined by 2.2 percent in 2009 (World Bank, 2010).

Despite the debate, few empirical examinations have explained whether the crisis augmented convergence or if it exacerbated structural inequalities. Pieterse (2011) and Bergstrem (2008) argue that the crisis destabilization of North economies presented opportunities for South economies to become independent from the North and they all took advantage of massive outsourcing of production from the North following the crisis that is associated with post-crisis economic growth. However, Saad Filho (2014) and Gore (2010) show that the crisis only exacerbated structural inequalities that have intensified South dependency on trading with the North. Thus, a clear understanding of how the crisis impacted the development of South economies remains lacking.

The theoretical literature presents conflicting findings of the 2008-2009 global economic crisis' impact on economic globalization and the world economy in general. For market economists, the crisis was a setback for globalization (Aslam et al. 2018; Ghironi and Levchenko 2018; van Bergeijk 2018), while political economy scholars argue that the crisis signaled a new epoch in economic globalization and predicted further integration of countries into the world economy for better (Gereffi 2014; Kaplinsky and Farooki 2011; Pieterse 2011) or worse (Robinson 2008). This dissertation chapter joins this debate by deriving competing empirical claims about the 2008-2009 crisis' effect on economic globalization and the structure of the world economy. This paper speaks this interdisciplinary literature that explores the impact of the 2008-09 global economic crisis on economic globalization.

To conduct this study for the dissertation, I seek to answer three questions central to sociological research on globalization and economic development: 1) *How did the global trade*

network adapt and respond to the 2008-09 global economic crisis? 2) *In what ways did the 2008-09 crisis affect economic inequalities between nation-states?* 3) *How did the 2008-09 crisis affect the dynamic interplay between the macro-level structure of the global trade network and economic productivity of nation-states?* To address these questions, I situate my study within social network analysis and economic sociology to advance a large-scale and longitudinal quantitative study of the aggregate global trade network throughout the period of the 2008-09 global economic crisis. Exploring the effect of a global economic crisis on the structure and dynamics of the global trade network advances the discipline by providing a unique analytical foundation in which to study the impact of contemporary global economic crises on structural inequalities at the macro- and micro-level of the world economy. To achieve this end, I collected and constructed one of the largest data sets of international trade networks from data provided by the International Monetary Fund's *Direction-of-Trade Statistics*, as well as econometric data from the World Bank's *Development Indicators* database.

Findings from this dissertation make several contributions to the literature on economic globalization in the post-2008-09 crisis era. First, findings from chapter 1 show that despite the impact of the 2008-09 crisis on international trade – the "Great Trade Collapse" (Baldwin 2009) – trade globalization continued to expand, albeit at a slower rate than in the pre-crisis era. In conjunction, the steady increases in connectivity and multilateralism was linearly associated with a global decentralization in outward and inward ties. These findings provide support for expectations of expanded international trade in the post-crisis era, rather than a widespread retrenchment in globalization. Second, findings from chapter 2 show that not only does the global trade network conform to a hierarchical, core-periphery structure, but this structure is

robust to crisis. Third, findings from chapter 3 show that this structure is a significant predictor of national economic productivity after the 2008-09 crisis.

Thus, these findings are in line with Cattaneo et al (2010) who found that the 2008-09 crisis did not reverse globalization due to resiliency of global trade networks. The structural features of the global trade network also proved resilient to the impact of the crisis; specifically, the hierarchical nature of the global trading system that has been historically divided between the "core" Global North countries and the "periphery" and "semi-periphery" countries of the Global South. In addition, the hierarchical nature of the global trade network played a substantial role in post-crisis economic productivity. In sum, the following three chapters provides a global perspective on the crisis and its impacts on globalization, inequalities, and national economic productivity. A final fourth chapter summarizes the main findings, highlights the contributions to the discipline, and provides directions for future research.

CHAPTER 1:

Economic Globalization in Peril? A Network Analysis of the Global Trade Network in the Wake of the 2008-2009 Global Economic Crisis

ABSTRACT

How did the 2008-2009 global economic crisis affect connectivity within the global trade network? The collapse of the US subprime mortgage market triggered a massive global economic recession that brought the largest economies in the world to near collapse. The global impact of the crisis underscored the role of economic globalization–in the form of globalized trade and production of goods and services–in facilitating the speed and transmission of its widespread impact. While there is considerable agreement that the 2008-2009 crisis severely affected economic relations between markets, nation-states, firms, and regions, there is less agreement on *how* much the crisis affected the long-term trend of greater global connectivity and clustering. More than a decade after the 2008-2009 crisis, few empirical studies have explored the degree to which the 2008-2009 crisis affected connectivity in the global trade network. Two central research questions guide this study. First, does the international trade network exhibit significant changes in bilateral and multilateral trade between a pre- and post-crisis period? Second, does the global trade network exhibit structural changes after the 2008-2009 global economic crisis? To answer these research questions, I use social network analysis to examine international trade data between 191 countries from 2001 to 2017. The data analysis reveals two important trends. First, connectivity and multilateralism grew steadily over the first 17-years of the 21st century and this growth was not hindered by the impact of the 2008-09 crisis on international trade. Second, this growth in connectivity and multilateralism is associated with a steady decentralization of inward and outward ties across the entire global trade network. The

results demonstrate that trade globalization continued to grow after the crisis, but not to the extent as in the pre-crisis period.

1.1 Introduction

There is considerable agreement that national economies have become increasingly interconnected because of cross-border flows of trade, production, investment, and finance, otherwise known as economic globalization. Economic globalization makes it possible for a greater number of consumers to buy foreign goods and services, and for a high number of multinational firms to operate across national borders. The proliferation of preferential trade agreements among a subset of countries based on geographical region and/or shared trading partners motivated a greater share of national economies to participate in this global process. This global interconnectedness provides opportunity for economic growth but also exposes national economies to the volatilities of an ever-globalizing world economy.

The 2008-09 global economic crisis underscored the role of economic globalization in the speed and transmission of its worldwide impact. There is consensus that the 2008-09 crisis severely affected relations between nation-states, firms, markets, and regions, but there is less agreement as to the degree to which the impact of the crisis affected economic globalization in its aftermath. The literature presents conflicting predictions as to the 2008-09 crisis' impact on economic globalization. For some economists, the crisis was a setback for further economic globalization (Aslam et al. 2018; Ghironi and Levchenko 2018; van Bergeijk 2018), while scholars of global political economy argued that the crisis signaled a new era of global integration that centered on increasing collaboration between Global South countries (Gereffi 2014; Kaplinsky and Farooki 2011). The debate amongst global political economy scholars was whether the 2008-09 crisis accelerated or decelerated a historical trend of Asian, Africa, and

Latin American countries gaining a greater share of global trade flows (see Pieterse 2011). Despite the debate, a lack of empirical literature continues to leave the issue uncertain and thus unresolved.

This study attempts to answer two central research questions related to these phenomena. First, *does the international trade network exhibit significant changes in globalization between a pre- and post-crisis period?* Second, *has the network structure become more or less centralized after the 2008-09 global economic crisis?* To answer these research questions, I examine data on international trade linkages between 191 countries with social network methods to examine the global trading system as a complex and interdependent network. Social network analysis is suitable for analyzing economic globalization because international trade is a specific type of social interaction connecting multiple nation-states through cross-border economic exchange (Kim and Shin 2002). Thus, I incorporate network measures that incorporate not only the volume of trade, but also the degree of connectivity and clustering before and after the 2008-09 crisis. These components demonstrate the level of globalization that has occurred in the wake of the crisis. I also include two measures of centralization (in- and out-degree centralization) to gain a profile of the aggregate structural composition and a measure of degree centrality to illustrate meso-level changes in centrality amongst geographical regions. This will allow me to explore the regions that are gaining a greater share of trade flows over time. I then proceed with a series of conditional uniform graph distribution tests to validate that the measures I observed are far from what could be expected given certain network properties. I find that despite the volume of trade remaining stagnant after the 2008-09 crisis, the global trade network has become much more interconnected and its structure more decentralized. However, I also find that these trends decelerated after the 2008-09 global economic crisis.

The paper is organized as follows. The following two sections describe the analytical framework of the study and a brief discussion of the global impact of the 2008-09 crisis, respectively. The fourth section applies concepts and methods from network analysis to examine properties of the global trading network. I describe a typology of network measures, and then discuss the data and propose measures of global and local economic integration. The fifth section summarizes the findings and suggests areas for future research.

1.2 Analytical Framework

Over the past four decades, a rich bank of literature within sociology, and the social sciences in general, has drawn upon social network analysis and international network data to comprehend both "globalization" as a concept and its impact on the world economy at both the micro (local)- and macro (global)-level. A hotly contested term, "globalization" can be described as increased interconnectedness and interdependence between societies, states, firms, and institutions. For sociologists of globalization, contemporary social phenomena cannot be understood solely at the level of an individual nation-state, but as by-products of inter-state relations that have evolved over time (Sklair 1999:144). Social network analysis helps scholars understand the influence of these inter-state relations in shaping an aggregate structure of the global trade network. Prior research demonstrates the relevance of network structure for understanding social processes, including interpersonal influence (Friedkin and Johnsen 2011), the transmission of infectious diseases (Klovdahl et al. 1994; Luke and Harris 2007), and information diffusion (Wejnert 2002). The notion of a global economic network is widely used as an analytical framework to underscore the relevance of transnational relations between societies, states, firms, non-governmental organizations, and many others (see for instance, Castells 2011).

As economies across the world become increasingly globally interdependent, social network analysis provides considerable analytical leverage on such diverse topics as the emergence of rising markets in the Global South, the spatial and temporal expansion of production and manufacturing activities across regions, and structural composition of the global trading system. Therefore, it is unsurprising that plenty of literature exists that applies social network analysis to the study of economic globalization. Many studies apply a world-system theoretical approach because at the heart of this theory is the intuition that the global trading system exhibits a hierarchical structure, otherwise known as a core-periphery structure. According to the literature, this structure shapes the opportunities and challenges of participating nation-states and their experience in their pursuit of national economic development. Much of the literature focuses on the 1) the extent to which cross-national relational data exhibit a core-periphery structure (Mahutga 2006; Nemeth and Smith 1985); 2) delineate boundaries between core and peripheral countries (Kick and Davis 2001); 3) adjudicate between the core-periphery distinction as a discrete or continuous variable (Smith and White 1992); and 4) assess the hypothesis that variable forms of "unequal exchange" occur across different zones in the core-periphery structure (Clark 2010; Mahutga and Smith 2011).

Social network analysis provides a structural approach to examine relations between nodes (or actors) in a social system and has its own unique concept of a core-periphery structure that parallels some of the structural lines of thought within world-system theory. The logic behind the analytical operationalization of the core-periphery structure with social network analysis methods is to determine whether patterns of international trade between countries constitutes a relational structure in which some positions - core positions - are associated with relatively higher benefits and autonomous activity while other positions - peripheral positions -

are associated with lower benefits and more constrained or dependent activity (Lloyd, Mahutga, and deLeeuw 2009: 52). This general approach has been treated extensively in social science literature - both with reference to the world economy and with the other substantive areas (for instance, see Alderson and Beckfield 2004; Kali and Reyes 2007; Mahutga 2006; Mahutga and Smith 2011; Smith and White 1992; Snyder and Kick 1979). Conventional methodological approaches within these studies are the use of blockmodeling to identify the core-periphery structure, pinpoint a country's position within the structure, and detect change in positions (Mahutga 2006). Others integrate positional measures into OLS regression models to examine the relationship between structural position and economic development (Clark 2010; Mahutga and Smith 2011).

However, little attention has been paid to the distribution of aggregate structural properties for dynamic international trade networks, especially with the proliferation of economic globalization in the 21st century. Such questions are of increasing relevance given the growing availability of network data suitable for studies of economic globalization, trade, development, and global inequality in the 21st century. Moreover, the rise of study designs that involve the collection of data on multiple networks of international economic exchange over a unique period in history are becoming increasingly popular in the social sciences. I provide a methodological contribution to the study of economic globalization. To achieve this end, I rely on a general analytical approach to network inference: univariate conditional uniform graph (CUGs) tests for evaluating graph-level properties. CUG tests provide a relatively straightforward way to assess whether a graph-level characteristics (such as density and degree centralization) occurs at a level that departs from chance, given lower-order graph features (such as network size and the number of edges) (Butts 2011; Faust and Tita 2019). Graph level indices

quantify aggregate structural properties of the network and are also useful for determining the large-scale structural context in which network behavior occurs. Thus, it is functional for modelling network structures, where they serve to provide structural signatures for underlying dependencies among edges (Pattison and Robins 2002).

In the subsequent section, I provide a succinct overview of the 2008-09 global economic crisis and its impact on the global trading system. I then review the theoretical debates to motivate testable hypotheses. Subsequently, I discuss the data and methods that will empirically test these hypotheses.

1.3 2008-09 Global Economic Crisis

The 2008-09 Global Economic Crisis refers to the massive economic turmoil the world economy experienced from 2008 to 2009. While the 2008-09 global economic crisis began as a financial crisis, a mechanism in the transmission of the crisis' impact was the pervasive and complex globalization of trade and production that have grown in prominence since the turn of the late 20th century. In turn, the impact of the crisis was felt globally because it severely affected both global financial markets and the "real" economy of production and trade. The crisis largely affected the largest economies of the world (The US, Western Europe, and Japan), which experienced an unprecedented 7.5 percent decline in real GDP during the 2008-09 period (International Monetary Fund 2009). According to the Washington Post, in the US, Americans lost $9.8 trillion in wealth as their home values plummeted and retirement accounts vaporized (Merle 2018). Unemployment also climbed and peaked at 10 percent by the end of October 2009. As for global economic growth, the crisis led to a loss of more than $2 trillion, or a drop of nearly 4 percent between its pre-crisis peak at the end of 2008 and the low hit at the beginning of 2009. Overall, the global Gross Domestic Product (GDP) is estimated to decline by 6 percent by

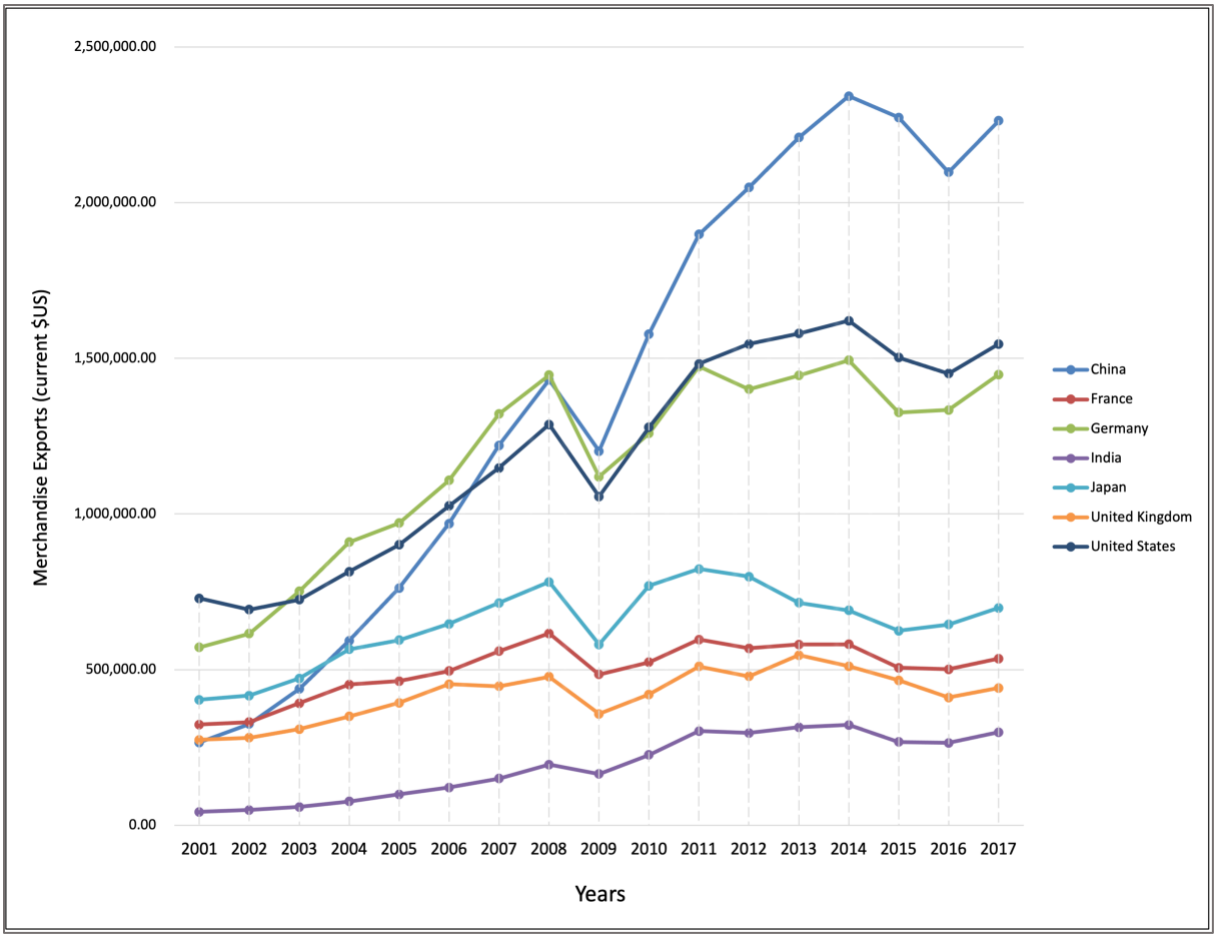
the end of 2008, a dramatic change from a 4 percent growth in 2007 (International Monetary Fund 2009).

Thus, the impact of the crisis on the world economy was felt quickly and broadly. This was due to the collapse in international trade and financial problems that originated in the US and quickly transmitted to Western Europe and Japan (Amiti and Weinstein 2011; Baldwin 2009; Chor and Manova 2012; Eaton et al. 2016). The largest markets in the Global North (i.e., the US, Western, and Japan) experienced an unprecedented 7.5 percent decline in GDP by the end of 2008 (compared to the 4 percent increase the previous year) (International Monetary Fund 2009). The severity of and recovery from the crisis' impact varied across countries. Figure 1.1 shows the sharp decline in merchandise exports in 2009 and across the major economies of the world, especially the US, UK, China, Germany, France, and India. Industrial production and merchandise trade plummeted across the world as demand for goods and services in these large markets declined rapidly (International Monetary Fund 2009). For many developing and emerging countries, their domestic industries rely on international trade. For many of smaller developing countries, international trade makes almost 50 percent of their national GDP (World Bank 2010a). In turn, the 2008-09 crisis' severe impact on international trade amongst the largest economies spilled over into smaller developing countries, most notably in Sub-Saharan Africa (Allen and Giovannetti 2011; Friedman and Schady 2009, 2013) and Asia (Ravallion 2009).

As mentioned earlier, the 2008-09 global economic crisis underscored the role of global trade and production in transmitting the impact of the crisis. Moreover, it exposed the vulnerability of smaller and developing Global South countries to external shocks and the low resiliency of countries where social protection mechanisms are not appropriate or fully implemented (Baldwin 2009). The impact of the 2008-09 crisis on a country's capacity to

maintain economic output to trade varied across countries and depended on factors related to a country's trading profile including specialization of trade, main export and import markets, dependence on finance markets, degree of internationalization of domestic firms, place on the value chain, and so on (Allen and Giovannetti 2011).

Figure 1.1 *Impact of the 2008-2009 Global Economic Crisis on the Merchandise Exports of Largest Global Economies (Source: World Bank Database)*



Many areas with clusters of fragile economies, such as Sub-Saharan Africa, are integrated into the world economy as central exporters of raw materials. Most of these countries rely on international trade as a vehicle to access larger markets for their own national economies to grow. As a result, despite their integration into the world economy, many of these "fragile economies" proved to be the least capable to offset the severe impact on global trade, given their

low fiscal capacity and lack of formal (and often informal) safety-nets (Allen and Giovannetti 2011). Many countries in the Global North also suffered their own consequences. In the US and the European Union, national governments are dealing with languishing economic problems including spiraling national debt, the loss of millions of jobs, stagnation of wages, and disappearance of domestic firms and industries.

By 2010 international trade and economic growth began to slowly recover to pre-crisis levels. World trade recorded its largest ever annual increase in 2010 as merchandise exports surged 14.5 percent, buoyed by a 3.6 percent recovery in global economic output as measured by gross domestic product (GDP) (World Trade Organization 2011). Both trade and economic output grew faster in Global South economies than in Global North economies. The GDP of Global North economies rose to 2.6 percent in 2010 after falling 3.7 percent in 2009, while the rest of the world's GDP grew 7.0 percent in 2010 compared to a 2.1 percent decline in 2009 (World Trade Organization 2011). However, the lingering impact of the crisis on national economies raised concerns about a significant policy shift towards protectionism and other populist policies designed to mitigate against further globalization through international trade.

The adoption of trade protectionist policies, such as tariffs on imported goods, gained momentum after the 2008-09 global economic crisis, especially throughout the European Union, one of the largest global markets (Kee, Neagu, and Nicita 2013). Moreover, the political-economic volatility brought about by the 2008-09 crisis has been linked to a surge in populist social movements and politicians that advocate against further economic globalization of domestic industries in the US and the European Union (Aslanidis 2016; Aslanidis and Rovira Kaltwasser 2016; Streeck 2014). By 2016, the lingering economic uncertainty from the 2008-09 crisis and hostility towards economic globalization galvanized populist, anti-globalization social

movements that supported the presidential ambitions of Donald Trump and the Brexit movement in the US and UK, respectively. Almost no other countries in the world have such an influence on international trade and its system as the US and the UK. The Trump's administration's "America First" policy took a hardline stance against further trade globalization and increasingly undermined international trade between the US and its most important trading partners (Bown and Irwin 2019; Gurtov 2020). In Europe, large segments of the UK population voted to decouple Britain's membership in the European Union, otherwise known as the Brexit movement, and altered, for better or worse, trading relations between some of the largest markets in Europe. While the US and UK sought to radically alter their trade relations with the rest of the world, larger emerging economies of the Global South, especially China, India, and Brazil, expanded their role as exporters. Moreover, these countries worked with smaller developing countries, especially in Sub-Saharan Africa, to redirect the bulk of their trade from the US and Europe to growing markets in the Global South. As a result, trade *between* Global South countries outpaced trade between Global North countries between 2009 and 2013 (Malik 2013).

The social science literature presents conflicting theoretical interpretations and predictions of the 2008-09 global economic crisis and its impact on international trade, a central engine of economic globalization. For economists, the crisis predicted that economic globalization would scale back due to the severe impact on international trade (Aslam et al. 2018; Ghironi and Levchenko 2018; van Bergeijk 2018). Scholars of the global value chain (GVC) approach, on the other hand, argue that the crisis signaled a profound shift in the organization of the world economy that altered, but did not diminish integration of countries into the world economy (Cattaneo, Gereffi, and Staritz 2010; Gereffi 2014; Kaplinsky and Farooki 2011; Robinson 2015). These perspectives provide analytical leverage towards the study of the

2008-09 global economic crisis' impact on international trade in two ways. First, by situating its impact on long-term trends within the world economy we can understand whether the crisis' impact on globalization was substantial. Second, the focus on international trade not only provides a way to measure the crisis' impact on economic globalization, but it allows us to consider its impact on the multilateral relations between nations, firms, and regions that facilitate economic globalization. Multilateral trade partnerships are composed of multiple nation-states into political and economic unions with formal rules and regulations that coordinate and govern trade between members. This paper speaks to the interdisciplinary literature that explores the impact of the 2008-09 global economic crisis on economic globalization.

1.4 Theoretical expectations

For many economists, the 2008-09 global economic crisis was a setback for economic globalization due to the impact on international trade. Researchers point to the rise of populist governments that pursued protectionist policies aimed at deterring international trade (Ghironi and Levchenko 2018) and a growing aversion to foreign direct investment and immigration (Aslam et al. 2018) as signals that the world economy will become less reliant on international trade, a central engine of economic globalization. The decline in foreign direct investment generated a long-lasting decline in the exports and imports of goods and services (Bergin, Feng, and Lin 2018; Gutiérrez Chacón and Moral-Benito 2019). Policy protections that increase import protections have largely reduced the incentive to seek international trade (Bown and Crowley 2012) and thus diminishes the incentive to create international trade ties. Constantinescu, Mattoo, and Ruta (2020) argue that the 2008-09 global economic crisis signaled a structural shift in the relationship between trade and domestic economic output. Literature that analyzes global value and supply chains offer their own analytical interpretations of the impact of the 2008-09

crisis on global connectivity between larger and smaller Global South countries. Thus, from this theoretical perspective, the crisis accentuated a growth in economic relations between major parts of the global trading network, whose interests lie in strengthening their national and regional economies for ongoing global integration even after the impact of the crisis. As a result, it can be hypothesized that the crisis did not impede economic globalization because of the growing relations that had grown within Global South regions. Nevertheless, through the prism of market economists, these trade relations will not significantly raise the average volume of trade following the crisis. Thus, the first two hypotheses of this study are the following:

> H_1: connectivity will continue to increase despite the impact of the 2008-09 global economic crisis.
>
> H_2: connectivity will increase alongside a stagnant level of average dollar volume of bilateral trade.

For other global economy scholars, the crisis accelerated a profound shift in the gravity of global economic commerce from the Global North to the Global South, which is reorganizing the world economic system (Gereffi 2014; Kaplinsky and Farooki 2011, 2011; Kaplinsky and Messner 2008; Kaplinsky, Terheggen, and Tijaja 2011). The crisis revealed "the growing salience of markets in the [Global] South" (Cattaneo et al. 2010) and the role of larger economies such as China, India, and Brazil in stabilizing international trade. Gallagher (2014) research offers supportive evidence that growing economic connections between large emerging countries (i.e., China, India, Brazil, and Russia) and smaller developing countries managed to regulate cross-border economic flows in the wake of the 2008-09 crisis, despite the political and economic difficulty of doing so at the national level (also, see Bown 2017).

A key reason for this growing international trade, especially within the Global South, has been the proliferation since the 1990s of regional trade agreements across various regions such as

MERCOSUR in South America, CAFTA between Central America and the US, SACU in Sub-Saharan Africa, and ASEAN in Asia which stimulate multilateral trade (for specific case studies, see Abrahamson 2007; Jugurnath, Stewart, and Brooks 2007; Malefane 2021; Salazar-Xirinachs 2002). Early iterations of regional trade agreements and arrangements, such as NAFTA and the European Union, were designed to stimulate multilateral trade between regional partners. They were also designed as a means for smaller developing countries to engage in global trade by becoming integrated into localized and regionalized multilateral trade arrangements. They provide support for lower- and middle-income countries to participate in the global trade network (Gnangnon 2018).

Immediately following the crisis, attention grew to the emergence of a "Global South-South Cooperation" (Altinbaş 2013; Gosovic 2016a; Gray and Gills 2016; Kaul 2013; Singh Puri 2010). Global South regions and countries sustained the impact of the crisis by relying on existing multilateral relations built from multilateral trade arrangements to maintain steady levels of global economic productivity (Altinbaş 2013). "South-South Cooperation" reflected a new trend in global trade and development where Global South countries were less affected by the crisis. Nevertheless, the emergence of populist leaders in the Global North also reflects a growing retrenchment of already existing trade ties. Thus, based on the role of multilateral arrangements prevalent within the Global South and the decline of Global North countries in stimulating multilateral trade pacts, I posit that multilateral trade arrangements will lead to increased formation of trade ties between three countries where at least two have a prior existing trade relationship, or transitive trade ties. Thus, I hypothesize the following:

> H_3: After the 2008-09 crisis, there will be a greater presence of transitive trade ties in the global trade network

Along these lines, the growing partnership between these countries helped to maintain an open economic system while the larger economies of the world were reeling from the crisis. Thus, from this theoretical perspective, the crisis accentuated a growth in economic relations between the semi-peripheral and peripheral economies of the world economy, whose interests lie in strengthening their national and regional economies for ongoing global integration. As a result, it can be hypothesized that the crisis did not impede economic globalization because of the growing relations between Global South countries. The crisis also accentuated the status of large emerging Global South countries and resulted in a less hierarchical global economic system. This motivates a fourth and final hypothesis:

> H_4: The steady growth in connectivity and multilateralism after the 2008-09 crisis will occur alongside a more decentralized global trade network.

1.5 Social Network Concepts and Notation

Social network data consist of measurements on a variety of relations for one or more sets of actors. While a network can be viewed in numerous ways, the most appropriate is as a *graph*, G, which consists of *nodes*, N, joined by *edges*, E. In a graph, nodes represent actors and edges represent the relations between actors. Thus, a graph, G, consists of two sets of information: a set of nodes, $N = \{n_1, n_2, \ldots, n_g\}$, and a set of edges, $E = \{e_1, e_2, \ldots, e_h\}$, thus $G = (N, E)$. In a graph of a social network, an edge $e = \langle n_i, n_j \rangle$ is included in the set of edges, $e \in E$, if an edge (or tie) exists between the two actors in the network. A special type of graph is a *directional graph* (or digraph) where ties are *directed* if the edges are oriented from one actor to another. Each tie in a directed network is an *ordered pair* of distinct nodes, $E = \langle n_i, n_j \rangle$, such that the edge is directed from n_i (the *sender* of the tie) to n_j (the *receiver* of the tie). Global trade is an example of a directed network. A trade relation consists of *exports*, which are the goods and

services produced domestically that are sent to consumers in foreign markets, and *imports*, which are foreign goods that are received for domestic consumption. Simply put, exporters are the senders and importers are the receivers of a trade relation.

Furthermore, international trade can be thought of as another special type of graph: a *valued directed graph*. Valued graphs are the appropriate graph theoretic representation for the valued relations that exist within international trade. Within these types of graphs, the edges (or ties) that are present in the network carry a value. A valued graph consists of three sets of information: a set of nodes, N, a set of edges, E, and a set of values attached to the edge. Thereby, v_{ij} is the value of the tie from i to j and v_{ji} is the value of the tie from j to i. The number of edges in a set is denoted by |E|. For the case of international trade, the dollar amount of manufactured goods and services sent from one country to another represents a directional valued edge. A dyad in a valued graph has edges with unique values between the nodes. Each of set of edges $\langle n_i, n_j \rangle$ and $\langle n_j, n_i \rangle$ carries a specific value that is denoted as v_i and v_j, respectively. A valued directed graph presents challenges for social network analysis. The amount of manufactured goods and services that country *i* exports to country *j* can be different from the amount that country *j* exports to country i. There are two unique values, one for each possible edge for an ordered pair of nodes, and thus for $e_k = \langle n_i, n_j \rangle$ and $e_m = \langle n_j, n_i \rangle$; therefore, v_{ij} does not necessarily equal v_{ji} (for a more detailed discussion of valued graphs, see Wasserman and Faust 1994: 139-143). Another challenge is the applicability of network measures to valued data, since many of the standard measures (density, reciprocity, transitivity, degree centralization) can only account for binary network data. To overcome this obstacle, I dichotomized the global trade data based on a benchmark of total dollar volume of trade in a certain year (will be discussed further in *Data* section below). In turn, an adjacency matrix A_{ij}

contains dichotomous relation such that *Aij* = 1 for a dichotomous relation that is present and *Aij* = 0 for null ties.

I now turn attention to network measures that are used to measure patterns of connectivity and centralization measures that quantify the variability of individual actors' centrality within each observed network (Wasserman and Faust 1994). For this study, I will use five network measures to assess the impact of the 2008-09 crisis on economic globalization: density, reciprocity, transitivity, and both in- and out-degree centralization. These measures will help to identify the level of connectivity within the international trade network over multiple time points.

1.5.1 Network Size and Density

The size and density of a social network are important indicators for measuring network connectivity. Network size refers to the number of nodes in a network and is critical for the structure of social relations and formation of hierarchies within the network. As the number of actors increases, the number of possible relationships increases. The density of a graph, denoted as d, is a measure of how many ties between actors exist compared to how many ties between actors are possible. The index of network density, thus, is the ratio of observed edges to the number of possible edges for a given network. Computing the appropriate density measure requires knowledge about the type of network we are analyzing: an undirected or directed network. In an undirected network, the direction of the edge is not considered. That is, for each dyadic relation, there is no distinction between "sender" or "receiver." By contrast, in a directed network, the direction of the edge is considered and the distinction between "sender" and "receiver" is important. As such the density for a directed network is computed as:

$$d = \frac{|\mathrm{E}|}{g(g-1)}$$

The density of a graph goes from 0, if there are no edges present (|E| = 0), to 1, if all possible lines are present. If the density is equal to 1, then all dyads are mutual, and if the density is equal to 0 then there are no edges presented in the network. For valued networks, there is an additional approach to obtain a generalizable measure for density that will be used in this study. That is, for a valued graph, it is reasonable to average the values carried in an edge across all edges present in the network. Thus, the density of a valued graph, d_v, can be computed as:

$$d_v = \frac{\sum v_{ij}}{|\mathrm{E}|}$$

where the sum is taken over all the edges with omitted zeros which are considered absent edges. This computation produces the mean dollar amount of trade between pairs with active trade relationships, but it also represents the mean weight of edges present.

1.5.2 Reciprocity

To further examine longitudinal trends of connectivity in the global trade network, I rely on the network concept of *reciprocity* which considers mutual relations between two actors. Reciprocity refers to the proportion of nodes that are mutually linked within a directed network and is a useful indicator for estimating the degree of mutuality and reciprocal exchange in a network. In the case of international trade, two countries that import and export with each other are likely to continue that relation even after a devastating global economic crisis. Moreover, scholars of global trade and development have long studied the role of similarities between two countries, especially geographic, political, and cultural proximity, in generating mutual trade relations (Frankel 2019; Frankel, Stein, and Wei 1997; Mansfield, Milner, and Rosendorff 2002; Sheafer et al. 2014; Zhou 2010, 2011). Therefore, reciprocity captures mutual bilateral trade between two countries at the dyadic level that then provides a snapshot of mutual trade at the level of the global trade network. Carley (1991) research finds that mutual interaction between

actors engenders greater shared knowledge, which then leads to even more interaction. International trade is an example of this type of interaction, and at the dyad level, there are factors that engender mutual attraction between two countries that establish long-lasting partnerships (Zhou 2010, 2011).

Reciprocity, denoted as R, is measured as a proportion of the number of mutual edges to the overall number of edges in the network. It is computed as:

$$R = \frac{\sum ij\, A_{ij} A_{ji}}{\sum ij\, A_{ij}}$$

an adjacency matrix A contains all edges between actors the relations in question, and $A_{ij}A_{ji} = 1$ if and only if mutual ties exist between two actors; 0 if otherwise. Values range between 0 (i.e., no mutual ties in the network) to 1 (i.e., all links are mutual in the network).

1.5.3 Transitivity

To observe multilateralism, I follow Kali and Reyes (2007: 602) and measure the extent of multilateralism in the global trade network through the property of *transitivity*, which considers the unique relations between a triple of nodes in a graph. Multilateralism, in this context, refers to the process of organizing a trade partnership between a group of three countries and transitivity measures the proportion of triads that form between an "actor, their partner, and their partner's partner". For this study, if multilateral trade agreements were indeed in effect, and grew through the period of the crisis, we would expect the formation of this type of triadic relation to grow in the post-crisis period.

Transitivity is informative because it tells us about connectivity amongst subgroups within the larger network (Holland and Leinhardt 1976). Specifically, a relation is transitive if an edge or tie from n_1 to n_2 ($e_m = \langle n_1, n_2 \rangle$) and another edge from n_2 to n_3 ($e_k = \langle n_2, n_3 \rangle$) results to an edge between n_1 to n_3. That is to say, if the relation "is a friend of," then the relation is

transitive if whenever n_1 "selects" n_2 as a friend and n_2 "selects" n_3, then n_1 "selects" n_3 as a friend (example from Wasserman and Faust 1994: 181). A standard measure of transitivity is obtaining the proportion of triads in which two interconnected nodes have a common connection to a third node. In the case of international trade, transitivity examines the formation of triads that formed each year. Transitivity can be computed as:

$$T = \frac{\sum_{ijk}^{g} A_{ij}A_{jk}A_{ik}}{\sum ijk\, A_{ij}A_{jk}}$$

where the numerator counts the number of triads in which an interconnected pair i and j share a common edge with actor k. The denominator counts all dyads between *i* and *j* and between *j* and *k.* Essentially, transitivity measures the proportion of *ordered triples i* → *j* → *k* that are closed by a *i* to *k* tie. Note that since these trade ties are directional, T is computed based on these directional edges. In other words, a triad with direct edges i to j, j to k, and k to i is different from a triad with direct edges i to k, j to i, and j to k.

1.5.4 In- and Out-Degree Centralization

Degrees are very informative for the case of international trade. For instance, if the global trade network is foundational to the operation of the world economy, then a country with low degree would indicate that they are minimally connected to the world economy. Degree, denoted by $d(n_i)$, is the number of edges that an actor possesses and the higher the node's degree. The in-degree of a node, $d_I(n_i)$, is the number of edges that a node *receives* (or the edges that come to a node). The in-degree of node n_i is equal to the number of edges of the form $e_k = \langle n_j, n_i \rangle$, for all edges $e_k \in E$ and all $n_j \in E$. The out-degree of a node, $d_O(n_i)$, is the number of edges that a node *sends* (or the edges that depart from a node). The out-degree of node n_i is equal to the number of edges of the form $e_k = \langle n_i, n_j \rangle$, for all $e_k \in E$, and all $n_j \in E$ (example cited from

Wasserman and Faust 1994: 125). In a non-directional network, a degree centrality index is measured by the number of nodes adjacent to *i*. However, with directed data, there is the distinction of each tie being either an inward or outward edge. Thus, the following standardized measure for degree centrality is proposed:

$$C_D'(n_i) = \frac{\sum_{j=1}^{g} A_{ij}(i \neq j)}{(g-1)}$$

Where $C_D'(n_i)$ is the proportion of nodes that are adjacent to n_i and is independent of the size of *g*. This makes it applicable index for comparing across networks of different sizes.

However, it should be noted that we cannot examine aggregate structural properties with $C_D'(n_i)$ only. To examine aggregate structural patterns in the network, I measure the concentration of ties around a few nodes in the network through a *group degree centralization index*. "A centralization measure quantifies the range of variability of the individual actor indices" (Wasserman and Faust 1994: 179) With this measure of group degree centralization, I can observe whether a few actors attract a large and disproportionate number of ties, which often indicate a great deal of influence and prestige within the network. A completely centralized network is one in which only one node sends and receives edges from all other nodes. This is called a *star* structure and it is the most unequal possible type of network. Thus, I use Freeman's (1979) group-level index of centralization to measure the distribution of ties in the network with the following formula:

$$C_D = \frac{\sum_{i=1}^{g}[C_D(n^*) - C_D(n_i)]}{max\sum_{i=1}^{g}[C_D(n^*) - C_D(n_i)]}$$

The $[C_D(n_i)]$ in the numerator are the degree indices, while the $[C_D(n^*)]$ is largest observed value. The denominator is the maximum possible sum of differences in point centrality for a graph *g*. The denominator can be computed directly (see Freeman 1979: 229; and Wasserman

and Faust 1994: 180), and equals (g – 1)(g – 2). However, since the relations we are measuring are directional, then the denominator can be calculated to be $(g-1)^2$ (see Wasserman and Faust 1994: 199). Thus,

$$C_D = \frac{\sum_{i=1}^{g}[C_D(n^*) - C_D(n_i)]}{(g-1)^2}$$

becomes an applicable index to measure the extent of degree centralization within the network. The index is bounded by 0 and 1 and can be interpreted as the proportion of edges in the network that are controlled by an individual node. In other words, the index maximum value of 1 when one node chooses all other (g – 1) actors, and other nodes interact with this one, central node (Wasserman and Faust 1994: 180).

I use two measures of network centralization, in- and out-degree, to assess macro-level structural properties in the global trade network. In- and out-degree centralization measure the extent to which inward and outward ties are concentrated on a single actor or group of actors, respectively. From the above equation for degree centralization, I extract two distinct measures of centralization for a directional graph: in- and out-degree. In-degree centralization is an aggregate measure of the distribution *inward* ties across the entire network while out-degree centralization captures the distribution of *outward* ties. High levels of network (in- and out-degree) centralization often form a star-shape (or spoke-and-hub) network in which a single node is connected to a larger number of other nodes who themselves have very few ties amongst themselves. Centralization is influenced by the size and density of the network. As discussed before, Butts (2006) study shows the importance of network size and density in engendering changes in centralization. Large networks that reach a maximum density of 1 will experience degree centralization that equals zero (Freeman 1978). In other words, as the number of ties in a

large network increase, and the more actors receive a greater share of the overall ties in the network, the lower the centralization indices.

With the increasing volume of trade observed immediately following the period of the 2008-09 crisis, and the emergence of major players in the global trade network such as China, India, Brazil, South Africa, and South Korea, it is conceivable that the structure of the global trade network had begun to decentralize prior to the crisis and then continued to do so after the crisis. This implies that the structure of the network has become less star-like throughout the period of observation and the crisis did not do anything to hinder that trend.

1.5.5 Conditional Uniform Graph Distribution (GUG) Tests

To conduct this research, this paper applies a family of techniques that combines an existing approach to the identification of structural biases in network data known as Conditional Uniform Graph (CUG) tests. This study identifies five central graph measures in network analysis (density, reciprocity, transitivity, and two centralization measures; in- and out-degree) to determine whether patterns in the international trade network reflect a more globalized world economy that is also altering its structure. Given the above, these network properties will be used to test the stated hypotheses by comparing connectivity and clustering measures between a pre- and a post-crisis period. I use longitudinal network trade data to observe connectivity and multilateralism in the global trade network from 2001 to 2017. More specifically, I use the dichotomized trade data to compute these measures of connectivity and multilateralism (see *Data* section for description of dichotomization procedure). Furthermore, to determine whether these patterns are far from random, I use a general approach for inferential network statistics - conditional uniform graph (CUG) distribution test - provide a relatively straightforward way to assess whether or not a graph-level characteristics (such as transitivity) occurs at a level that

departs from chance, given lower-order graph features (such as network size, density, and the dyad census) (Butts 2011; Faust and Tita 2019). CUG tests can be interpreted as a significance test, yet the procedure of drawing random graphs from observed statistics can be used for other purposes. Graph level indices quantify aggregate structural properties of the network and are useful for determining the large-scale structural context in which behavior occurs (Anderson, Butts, and Carley 1999). Thus, CUG tests are functional for modeling network structures, where they serve to provide structural signatures for underlying dependencies among edges (Pattison and Robins 2002).

The null hypothesis of the CUG test is that the observed network characteristic was drawn from a distribution equivalent to that of said network characteristic that is being evaluated (uniformly) on the space of all graphs conditional on one or more features (Anderson, Butts, and Carley 1999). Specifically, with the CUG tests I examined the probability of observing a certain network characteristic (density, transitivity, reciprocity, etc.) given a certain lower-order property within the network (i.e., network size, number of edges, density). To conduct this analysis, I generated 1000 random graphs that are conditioned on a given lower-order network property which is dependent upon the statistic that is being assessed. For instance, the temporal CUG tests rely upon a series of 1000 random graphs that are conditioned on the density of two years prior. However, analyses of transitivity and both in- and out-degree centralization rely on random graph distributions conditioned on the dyad census of the observed network in each year. These random graphs provide a baseline distribution of particular network characteristics that then define a criterion for rejection of a null hypothesis that the observed network statistic is "typical" of those type of graphs with the aforementioned characteristics (Anderson, Carley, Butts 1999). Moreover, from the sampling process that generates the baseline distribution, it is possible to

derive *p*-values associated with null hypothesis. This procedure is comparable to standard hypothesis testing, such as a one-sided t-test, and provides clear interpretation of probabilities while controlling for lower-order network properties (Anderson, Carley, and Butts 1999).

To start, a CUG approach randomly generates graphs from a conditional uniform distribution, via Monte Carlo simulation, then constructs a reference distribution for graph-level characteristic of interest: density, reciprocity, transitivity, and both types of degree centralization (in- and out-) from the random graphs. It then locates the observed value of that graph-level property relative to the reference distribution. Thus, if the observed index is extreme relative to the random graph distribution, one can conclude that the observed value is unlikely to have arisen from the conditioning properties (Butts 2011). For density, I am conducting a temporal form of a CUG test where I will test the observed network statistic in year t against generated random graphs that are conditioned on the size and density of $t-1$. The logic of this temporal CUG test is to test whether the network became denser (interconnected) through time, which would indicate significant increases in trade globalization. For instance, the observed density in 2003 (t) will be compared to the random graphs conditioned on the size and density of the network in 2001 ($t-1$). For the other measures - reciprocity, transitivity, and centralization - I do a univariate CUG test to test whether the observed graph-level characteristic is unlikely to have arisen by chance, given certain network properties. For instance, reciprocity is conditioned on the size and number of edges while both transitivity and centralization are conditioned on the dyad census. Conditioning on the dyad census uses the U|MAN distribution (Holland and Leinhardt 1976), which is a uniform distribution that conditions on three elements: the number of mutual, asymmetric, and null dyads in a directed graph. The U|MAN distribution is useful because it conditions on the lower-level properties of the complete dyad census, such as the

tendency towards reciprocity, and, by mathematical necessity, it conditions on the density of the observed graph (Felmlee et al. 2018: 4). Similarly, the procedure draws randomly generated graphs that serve as a reference distribution for the observed statistic.

1.6 Data

For this study, I constructed an original dataset of the international trade network from the International Monetary Fund's *Direction of Trade Statistics* from 2001 to 2017 and for a sample of 191 countries/territories. To construct my network data of international trade, I used publicly available data from the International Monetary Fund's *Direction of Trade Statistics (DOTS)*, which includes bilateral merchandise trade data for various countries and territories over a 1948-2018 period International Monetary Fund (2014). The DOTS data present the total value of exports and imports of all member countries of the International Monetary Fund (IMF). DOTS captures pair-wise trade flows between countries measured in current US 100 million dollars with no inflation adjustment. Although the data sources give information on both exports and imports, a consensus within the literature is that there is reason to believe that import data are more accurate than export figures (Kim and Shin 2002; Mahutga 2013). I constructed trade data into 9 adjacency matrices that contain ordered, directed trade flows between countries. Within my constructed data, I measured trade flows for 191 countries for 9 unique time periods (2001, 2003, 2005, 2007, 2009, 2011, 2013, 2015, 2017). To account for skewness, I transformed the raw data using the log transformation of $\log(x_i + 1)$. To impute missing data, if there was no available import data of *Country A* from *Country B*, I relied on the available reported export data from the same DOTS database. All other non-reported import or export data between two countries was treated as 0 to indicate either zero or less than $US 100 million international trade.

As mentioned earlier, the network measures of this study are applicable to binary network data only. Therefore, I dichotomized trade relations based on the $US 100 million international trade network for two reasons. First, since the international trade data encompasses a large sample of nation-states with disparate economies of scale and population sizes, the $US 100 million benchmark would avoid excluding several trade relations with much smaller nation-states. Because the mission of the project is to examine the entire global trade system, it was important to include as many trade relations as possible. Second, previous analyses with higher benchmarks produced near similar results and patterns, and differences were minor and appeared trivial.

This is a large sample considering the number of independent nation-states that have emerged since the end of the Cold War. In addition, several countries gained independence during the period of investigation. To maintain a consistent sample size across multiple time periods, I aggregated the trade flows of recently independent nation-states as part of their former republics' overall trade, a strategy that branches off a similar approach by Mahutga (2013). I did this for only two countries: Serbia and Montenegro and Netherlands Antilles. The republics of Serbia and Montenegro were once a single federal and political unit that officially became the State Union of Serbia and Montenegro in 2003. In 2006, Montenegro seceded from the union which led to the recognition of Serbia and Montenegro as independent states. Moreover, Kosovo officially declared its independence from Serbia in 2008. In turn, I aggregated the trade data of Kosovo, Serbia, and Montenegro and categorized them under the country label of "Serbia and Montenegro," the name of its former republic, for all time periods under investigation. I followed a similar strategy for the Netherlands Antilles and Curacao as the latter country gained official

independence from the former in 2010. I aggregated the data of Curacao with its former colonizer.

In sum, 191 countries appear in this sample if they either reported imports in every year, or I could rely on export-data from the DOTS data and temporally approximate flows between non-reporting countries for no more than one missing year. The full sample is representative of all world regions. I constructed 9 asymmetrical (directed) matrices of international trade, representing each of the selected years. The columns and rows consist of 191 countries, and the cells represent the dollar volume (in $US 100 million) transformed using log+1 transformation. The rows represent export (sender) relationships and columns represent import (receiver) relationships. Furthermore, since all the network measures I use only consider the presence or the absence of a tie, I dichotomized each trade relation and considered the presence of a tie any trade relation that generated at least $100 US million or more in volume each year. Therefore, any trade relation that generated above the benchmark was coded as "1" and "0" otherwise. For the data analysis, I used R Studio and the *Tools for Social Network Analysis* (sna) package developed by Butts (2008).

1.7 Results

1.7.1 Connectivity: Density and Reciprocity

Hypotheses 1 and 2 predicted that 1) connectivity in the form of trade globalization will continue to increase despite the impact of the 2008-09 global economic crisis on global trade network and 2) that average dollar volume of trade will remain stagnant, nevertheless. Table 1.1 presents the network statistics of the international trade network from 2001 to 2017 and the results support hypotheses 1 and 2. Density reflects the extent of connectivity in a network (Blau 1977); that is, the higher the density, the more connectivity is present in the network (Kim and

Shin 2002). Network density also displays a monotonic increase from 2001 (d=0.573) to 2017 (d=0.701). Figure 1 displays the trends in the mean dollar volume of trade between two countries.[2] Mean $US volume of trade measures the level of productivity that is generated by a trade tie between two countries each year. The sharp decline in mean dollar volume from 2007 to 2009 displays similar trends as shown in figure 1.1. There is a similar increase from 2009 to 2011 that reflects a large yet brief recovery in global trade after the crisis. Overall, there was a 180 percent increase in the mean trade in dollar volume from 2001 to 2017. However, there was a -2.16 percent decrease from 2011 to 2017 (the post-crisis period) compared to a 123 percent increase from 2001 to 2007 (the pre-crisis period).

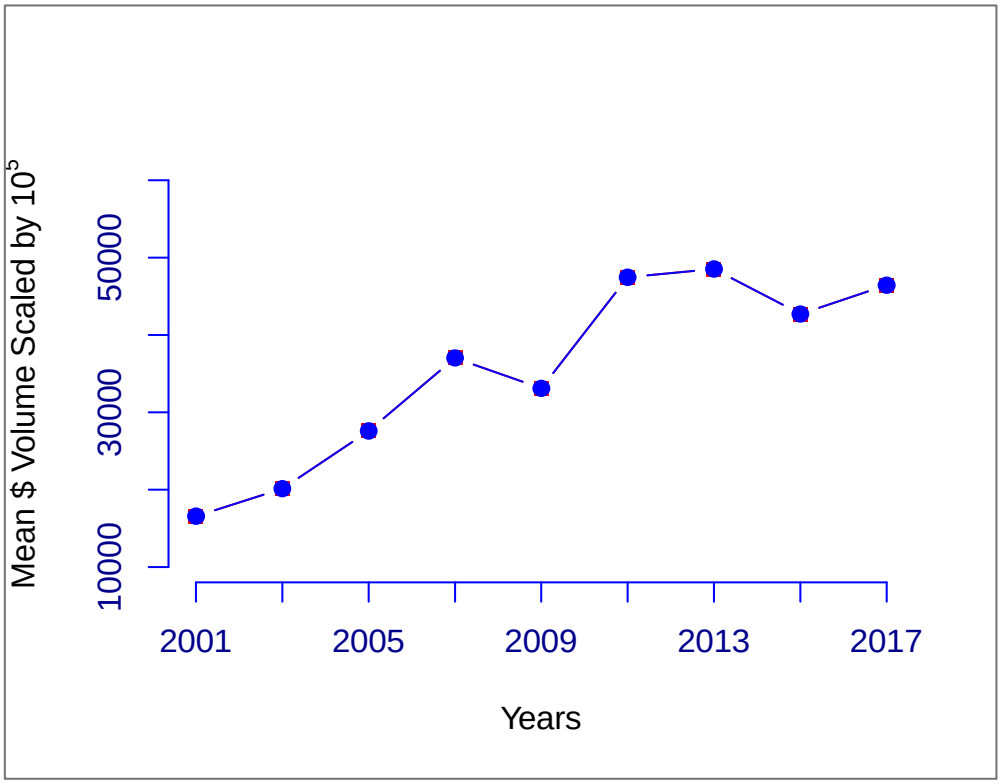
Table 1.1 also presents the measures for density and reciprocity. From 2001 to 2017, density increased monotonically while reciprocity does not appear to have experienced significant changes, either up or down. For instance, density increased from 0.573 in 2001 to 0.701 in 2017, which was a 22 percent increase compared to reciprocity which only increased from 0.763 in 2001 to 0.769, a less than one percentage point increase. This trend is illustrated in figure 1.3 below. These descriptive statistics show an overall growth in connectivity and productivity within the global trade network from 2001 to 2017, but when comparing pre- and post-crisis periods the evidence shows a slowdown in connectivity and productivity after the 2008-09 crisis. Thus, the evidence provided supports the claims of hypothesis 1 and hypothesis 2.

[2] This measure considered those pairs of countries that traded each year. It did not include i, j cells that contained 0. Moreover, the mean $US volume of trade that is presented in figure 1.2 is scaled by 10^5 for displaying purposes.

Table 1.1 *Graph-Level Indices of International Trade Network, 2001 - 2017*

Years	Total Edges	Mean $US in Trade	Density	Reciprocity	Transitivity
2001	20,793	165,598,267	0.573	0.763	0.74
2003	21,684	201,188,666	0.598	0.759	0.753
2005	22,017	275,782,921	0.607	0.764	0.759
2007	22,761	370,138,864	0.627	0.757	0.771
2009	23,492	330,847,043	0.647	0.754	0.785
2011	24,333	474,476,011	0.671	0.768	0.797
2013	24,672	485,153,808	0.68	0.769	0.803
2015	25,197	427,023,526	0.694	0.771	0.809
2017	25,447	464,235,404	0.701	0.769	0.815

Figure 1.2: *Trends in mean volume of bilateral trade (scaled) from 2001 to 2017*



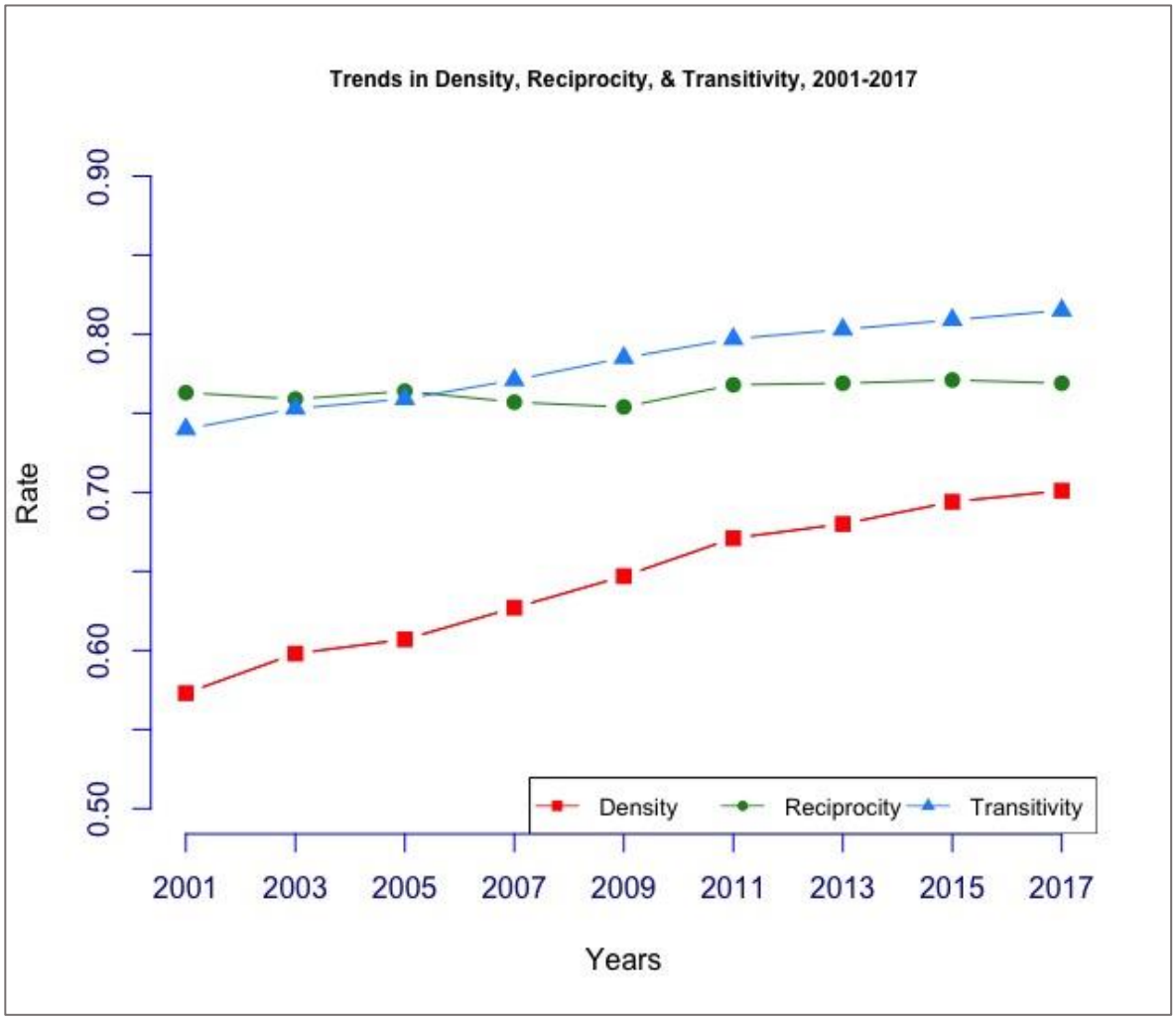
From these findings, I highlight two major patterns relevant to the study of the global trade network from 2001 to 2017. First, connectivity in the global trade network has steadily increased since the dawn of the 21st century and continued to increase monotonically even after the 2008-09 crisis. Essentially, trade globalization was robust to the "great trade collapse" (Baldwin 2009) and while new ties do not appear to have generated significant changes in reciprocity, findings nevertheless show that existing mutual ties were also robust to the impact of the crisis. Second, while there was a steady and stable increase in connectivity, the average volume of trade generated within the global trade network was severely impacted by the crisis. As figure 1.2 displays, there was a sharp drop in the average dollar volume in trade over the period of the 2008-09 crisis. After 2009, there was sharp yet brief increase in average dollar volume in trade from the end of 2009 to 2011. After 2011, the average dollar volume remained stagnant thereafter. Thus, the results show that although the mean dollar amount of trade fluctuated throughout the period of observation, the number of trade partnerships increased consistently even after the 2008-09 crisis, which support the predictions of hypotheses 1 and 2.

1.7.2 Multilateralism: Transitivity

To test hypothesis 3 – multilateralism will continue to grow after the period of the crisis – I observed rates of transitivity over the 17-year period and compared trends across pre- and post-crisis periods. Table 1.1 contains the rates of transitivity from 2001 to 2017. From 2001 to 2017, the rate of transitivity increased from 0.74 in 2001 to 0.815 in 2017, a 10.14 percent change. In addition, when comparing measures of density and reciprocity from table 1.1, it shows that the rate of reciprocity was consistently higher than the rate of density. This may indicate that the steady increase in density is associated with an increase in transitivity, which provides evidence of multilateralism within the global trade network. When comparing transitivity across pre- and

post-crisis periods, the multilateralism that had been growing since the start of the 21st century maintained itself after the crisis, albeit at a relatively slower pace. Nevertheless, the measure of transitivity provides further evidence of connectivity in the global trade network that was robust to the crisis. Furthermore, when comparing all three measures of connectivity (density, reciprocity, and transitivity), the evidence points to a durable system of interdependency within the global trade network that is worth further exploration. As global economic crises become more frequent yet different in character, it behooves scholars of globalization to examine the mechanisms that make these relations stable.

***Figure 1.3**: Long-Term Patterns in Density, Reciprocity, and Transitivity from 2001 to 2017*



1.7.3 Examining Structural Changes: In- and Out-Degree Centralization

To test the hypothesis that steady growth in multilateral trade will occur alongside a more decentralized global trade network after the 2008-09 crisis, I examined trends in measures of degree centralization which measures aggregate level trends in the network structure and a standardized measure of degree centrality to observe individual-level patterns of connectivity in relation to other actors in the network. In the case of international trade, degree centralization measures the extent to which trade ties in the global trade network are concentrated in a single country or a small group of countries. The measure of mean degree centrality, on the other hand, examine the properties of individual countries. In other words, countries with higher-than-average degree centrality tend to be more active in the global network versus those with lower-than-average degree centrality.

Table 1.2 presents the measures of degree centralization and the mean degree centrality. Both measures of centralization, in- and out-degree, illustrate that the concentration of inward and outward trade ties within a few countries has declined over time. From 2001 to 2017, both in-degree centralization and out-degree centralization declined from 0.424 to 0.3 and 0.403 to 0.284, respectively. The decline in the centralization measures occurred alongside a monotonic increase in mean degree centrality. In line with results from table 1.1, these measures of centralization and centrality reveal that connectivity has occurred alongside a pattern decentralization within the global trade network. Figure 1.4 illustrates that as density increases and reaches closer to 1, degree centralization reduces to near zero, which is a mathematical property (see Butts 2006). In other words, network centralization scales linearly with mean

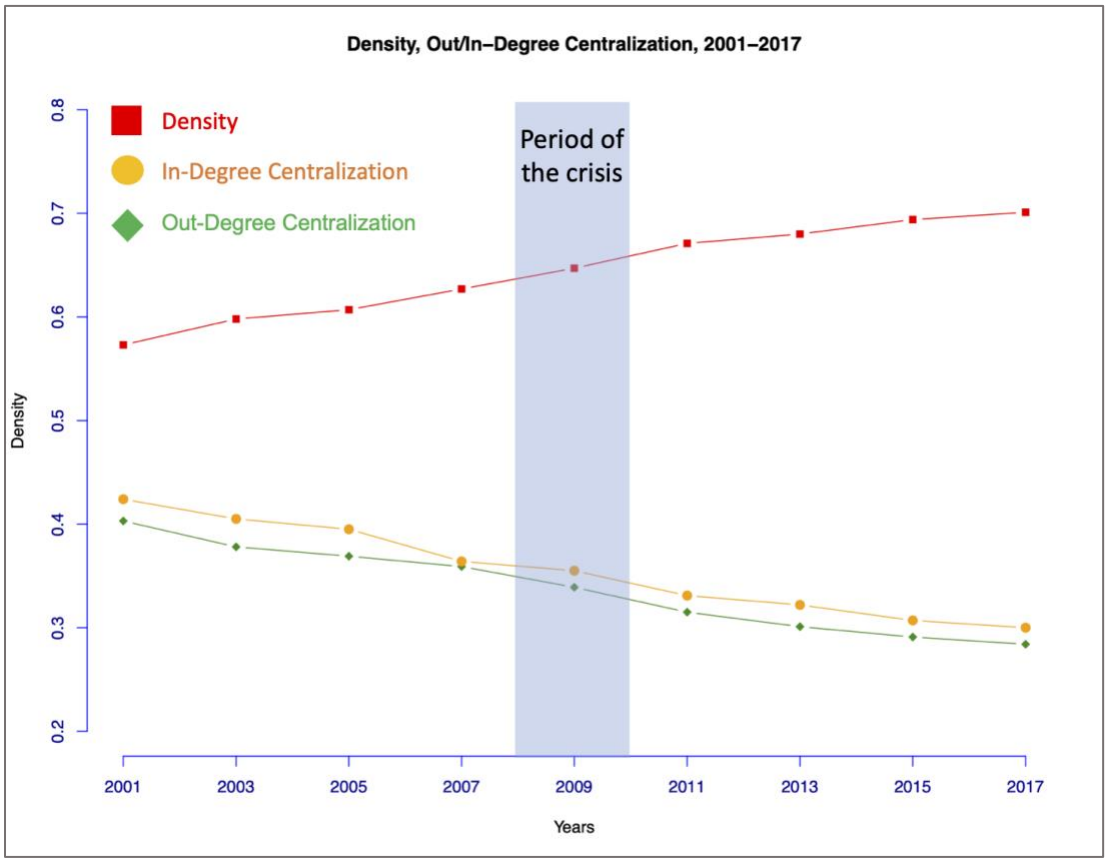
degree, such that graphs with high degree centralization cannot have high mean degree, and therefore the increase mean degree centrality along with rising density falls linearly with degree centralization (see Butts, 2005).

Within the context of globalization, increases in density and mean degree, along with a fall in centralization, reflects rising economic connectivity between nation-states, which aligns with standard definitions of economic globalization. Against the backdrop of the 2008-09 crisis, it is evident that the growth in international trade at the start of the 21st century resulted in a global trade network where the concentration of both inward and outward ties amongst a few countries has steadily diminished. In turn, countries have become increasingly interconnected and has shown to be robust to the impact of a global economic crisis. Therefore, the evidence provides support for hypothesis 4 that predicted that the growth in multilateralism and connectivity would occur alongside decentralization of the global trade network.

Table 1.2 *Measures of Degree Centralization and Centrality, 2001 to 2017*

Years	In-Degree	Out-Degree	Mean Degree Centrality
2001	0.424	0.403	109.44
2003	0.405	0.378	114.13
2005	0.395	0.369	115.88
2007	0.364	0.359	119.79
2009	0.355	0.339	123.64
2011	0.331	0.315	128.07
2013	0.322	0.301	129.85
2015	0.307	0.291	132.62
2017	0.3	0.284	133.93

***Figure 1.4**: Long-term patterns between density and (in-/out-) degree centralization, 2001-2017*



1.7.4 Robustness Checks: Univariate CUG Tests

Figures 1.5a and 1.5b[5] contain the plots of the CUG test plots that contain the 1000 generated random graphs that provide a reference distribution to compare the observed network density. For these temporal CUG tests, I compare the density at time t to 1000 generated random graphs where the observed density is equal to the observed density two years prior, $t - 2$. This would test whether the density in the later year is significantly different from what would be expected if the density remained the same as what was found two years prior. Table 1.3 presents the proportion of random graphs that have values greater than or equal to (or, less than or equal to) the observed value of the network statistic, and specifically for the observed statistics of

[5] All CUG test plots are placed in the "Supplementary Materials" section at the end of the document.

density, reciprocity, and transitivity. Table 1.4 presents the predictive probabilities for in- and out-degree centralization. Figures 1.6 and 1.7 contain plots for the CUG tests for in-degree and out-degree centralization, respectively, for each year of observation (also placed in 'Supplementary Materials' below).

First, figure 1.5a and 1.5b compare the baseline distribution of densities drawn from 1000 random graphs conditioned on density in $t - 2$ and the observed density in time t, from 2003 to 2017. From visual inspection, the density in time t is significantly greater than the density that would be expected given the observed density in time $t - 2$. This pattern is consistent across each period. The second and third column of tables 1.3 show the proportion of random graphs with statistics greater than or equal to the observed density across each year. The observed density at time t is greater than the density that would be expected given the density at time t-1 in more than 99.8 percent of all random graphs. These results further confirm that density increased over time. Therefore, the results from figures 1.5 and table 1.3 provide evidence that the density in each year was significantly greater than the density two years prior. These results substantiate claims that connectivity in the global trade network grew significantly greater than the density in the previous period. Therefore, it provides further evidence for support of hypothesis 1.

Second, figures 1.6 and 1.7 contain the plots for the CUG tests for transitivity and reciprocity, respectively, for each year of observation. When comparing the observed statistics of transitivity and reciprocity to those expected by the random graph distributions in each year, each network statistic is significantly greater than what would be expected given size and density for tests of reciprocity and size and dyad census for transitivity across each year. This interpretation is further supported by the results presented in the 5^{th} to 7^{th} column in table 1.3. These measures indicate that, in across all years, the observed amount of reciprocity is larger

than expected in random graphs of the same size and density. Similarly, the observed amount of transitivity is larger than expected in random graphs of the same size and with the same dyad census as the observed graph across all years. Therefore, the results provide further evidence that the connectivity and multilateralism that I observed in the global trade network data are far from what would be "typical" given certain network properties in the observed network across each year.

Table 1.3 *Proportions of Random Graphs with Statistics Greater/Less Than the Observed Network Statistics (Density, Reciprocity, Transitivity), 2001 - 2017*

	Density		**Reciprocity**		**Transitivity**	
Years	**Pr(Sig.Low)**	**Pr(Sig.High)**	**Pr(Sig.Low)**	**Pr(Sig.High)**	**Pr(Sig.Low)**	**Pr(Sig.High)**
2003	1.000	0.000	1.000	0.000	1.000	0.000
2005	1.000	0.000	1.000	0.000	1.000	0.000
2007	1.000	0.000	1.000	0.000	1.000	0.000
2009	1.000	0.000	1.000	0.000	1.000	0.000
2011	1.000	0.000	1.000	0.000	1.000	0.000
2013	0.998	0.002	1.000	0.000	1.000	0.000
2015	1.000	0.000	1.000	0.000	1.000	0.000
2017	0.998	0.002	1.000	0.000	1.000	0.000

Table 1.4 *Proportions of Random Graphs with Statistics Greater/Less Than the Observed In- and Out-Degree Centralization, 2001 - 2017*

	In-Degree		**Out-Degree**	
Years	**Pr(Sig.Low)**	**Pr(Sig.High)**	**Pr(Sig.Low)**	**Pr(Sig.High)**
2003	1.000	0.000	1.000	0.000
2005	1.000	0.000	1.000	0.000
2007	1.000	0.000	1.000	0.000
2009	1.000	0.000	1.000	0.000
2011	1.000	0.000	1.000	0.000
2013	1.000	0.000	1.000	0.000
2015	1.000	0.000	1.000	0.000
2017	1.000	0.000	1.000	0.000

Figures 1.8 and 1.9 display the univariate CUG distributions and the observed statistics for in- and out-degree centralization, respectively. As shown, the observed statistic for each network characteristic is significantly greater than what would have been expected given the dyad census of the observed network in each year. In other words, the observed in- and out-degree centralization measures in each year are significantly greater than the baseline distribution. In addition, the proportion of random graphs with statistics greater/less than or equal to the observed statistics presented in tables 1.4 show that the probabilities, along with the CUG test graphs, indicate that in across all years and for both centralization measures, the observed amount of centralization was larger than the amount of centralization in all of the random graphs. This provides evidence to reject a null hypothesis that the in- and out-degree centralization that were observed from 2001 to 2017 were "typical" of networks with a similar dyad census.

1.8 Discussion and Conclusion

Results from this study demonstrate that globalization continues to occur, especially following the 2008-09 global economic crisis, and the concentration of outward and inward trade flows is decentralizing. In sum, this paper advances an analytical framework for understanding an increasingly globalized world economy during an era of intense interconnectedness and volatility. This study contributes to the literature on the study of the 2008-09 crisis by providing a longitudinal analysis of the global trade network throughout the period of the crisis and thereafter. The results are from observations of patterns in network connectivity and multilateralism across the first 17-years of the 21st century.

Based on the results, despite the severe and lasting impact of the crisis on the average dollar volume of international trade, the global trade network continued to become increasingly interconnected after the crisis. While growth in connectivity and multilateralism were growing

prior to the crisis, this study finds that the crisis did not hinder this trend in the post-crisis era. This highlights the resiliency of trade globalization to the impact of a crisis that some termed the "great trade collapse" (Baldwin 2009). Furthermore, findings related to in- and out-degree centralization indicate that this long-term growth in connectivity has decentralized the concentration of inward and outward ties across the entire global trade network, thereby resulting in noticeable structural changes. As with connectivity and multilateralism, this trend of decentralization which began at the dawn of the 21st century was not hindered by the crisis either. Instead, it appears as though the growth in connectivity and multilateralism has increased the share of trade flows across the entire global trade network, thereby widening the distribution of prestige and influence across numerous other countries.

While these results provide empirical insights into long-term patterns within the global trade network, the study leaves issues for future research on the impact of global economic crises on economic globalization and international trade. However, although *ties* in the network are becoming less centralized (less concentrated) I did not examine whether inequalities in dollar amounts of trade are also becoming more or less unequal. Thus, the variance (inequality) of total imports or exports (in dollar totals) could be increasing even though the in- and out-degree centralization are getting lower. This motivates areas of future research that will be discussed further in the Discussion and Conclusion chapter. Also, comprehensive data on specific industries would give greater insight into which industries were more resilient than others. Nevertheless, the findings provide a launching pad for exploring how the international trade network responds to a massive economic downturn.

1.9 SUPPLEMENTAL MATERIALS

***Figure 1.5a**: Temporal CUG Tests for Density, 2001 to 2009*

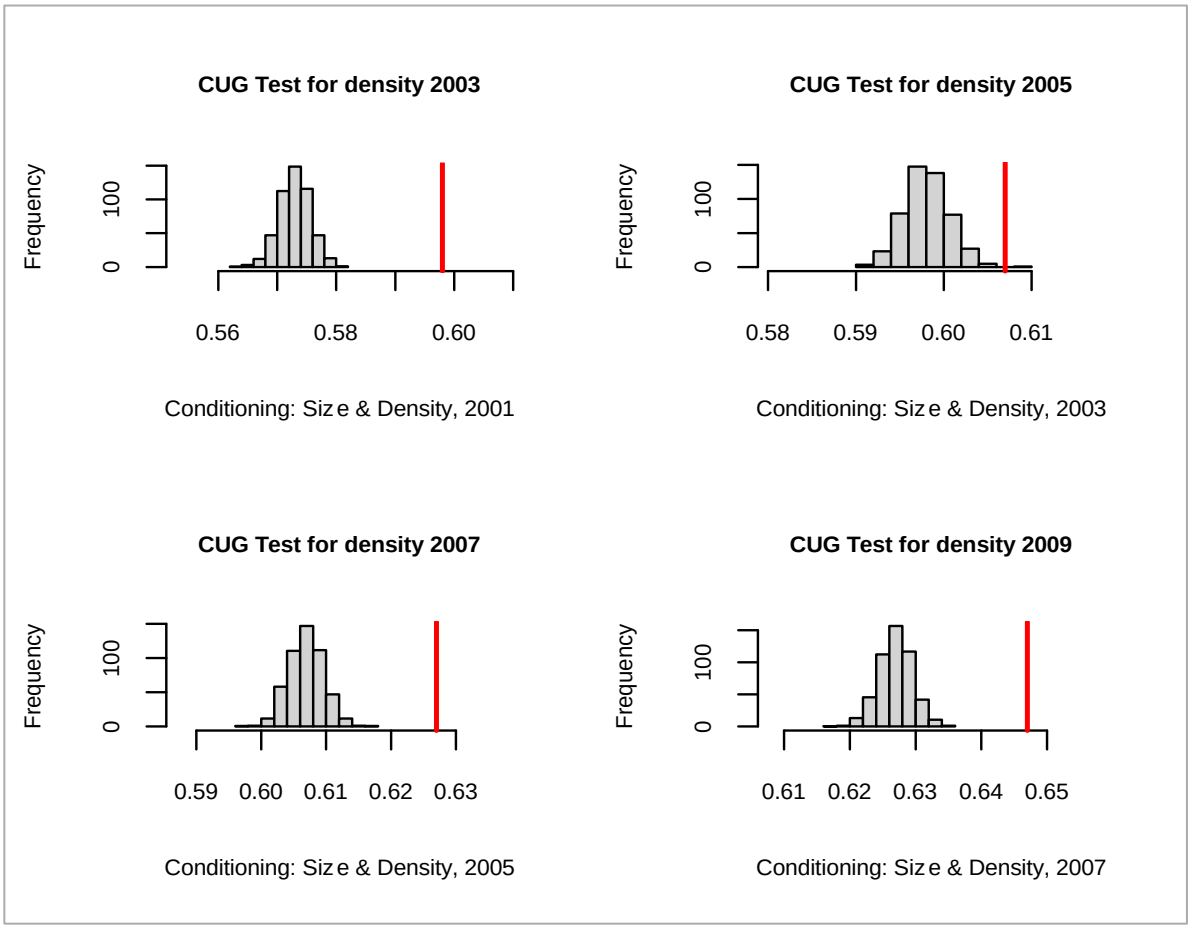


Figure 1.5b: *Temporal CUG Tests for Density, 2011 to 2017*

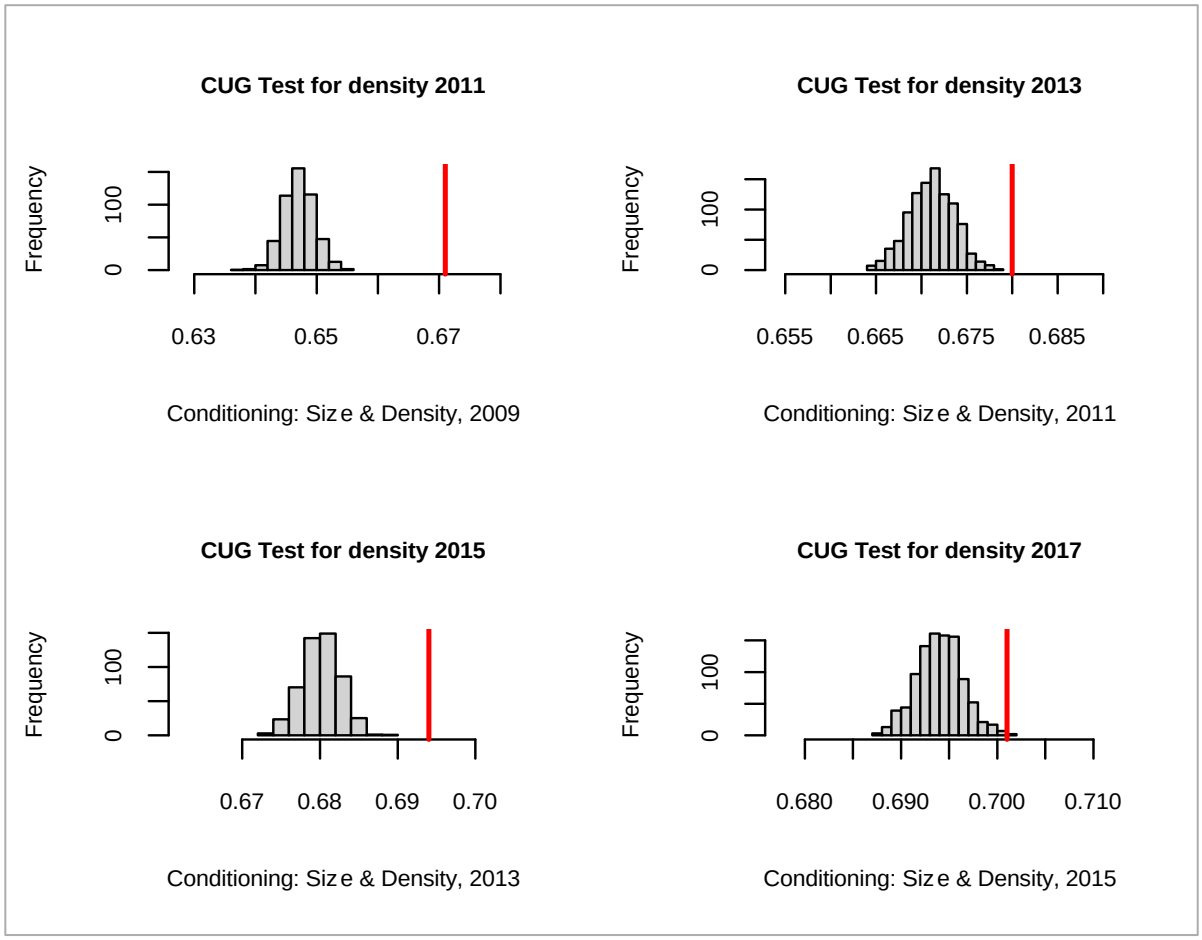


***Figure 1.6**: CUG Tests for Reciprocity, 2001 to 2017*

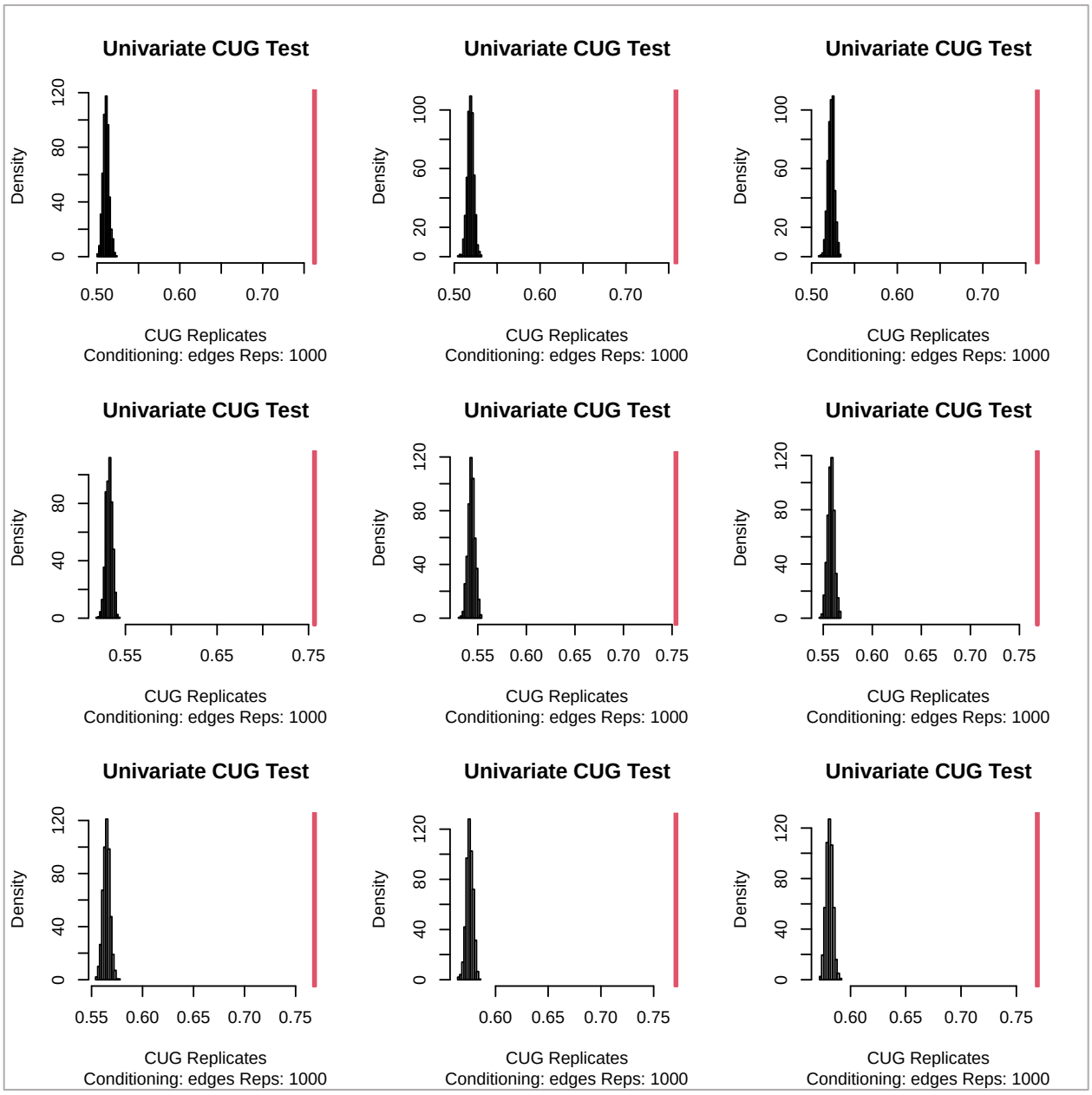


Figure 1.7: *CUG Tests for Transitivity, 2001 to 2017*

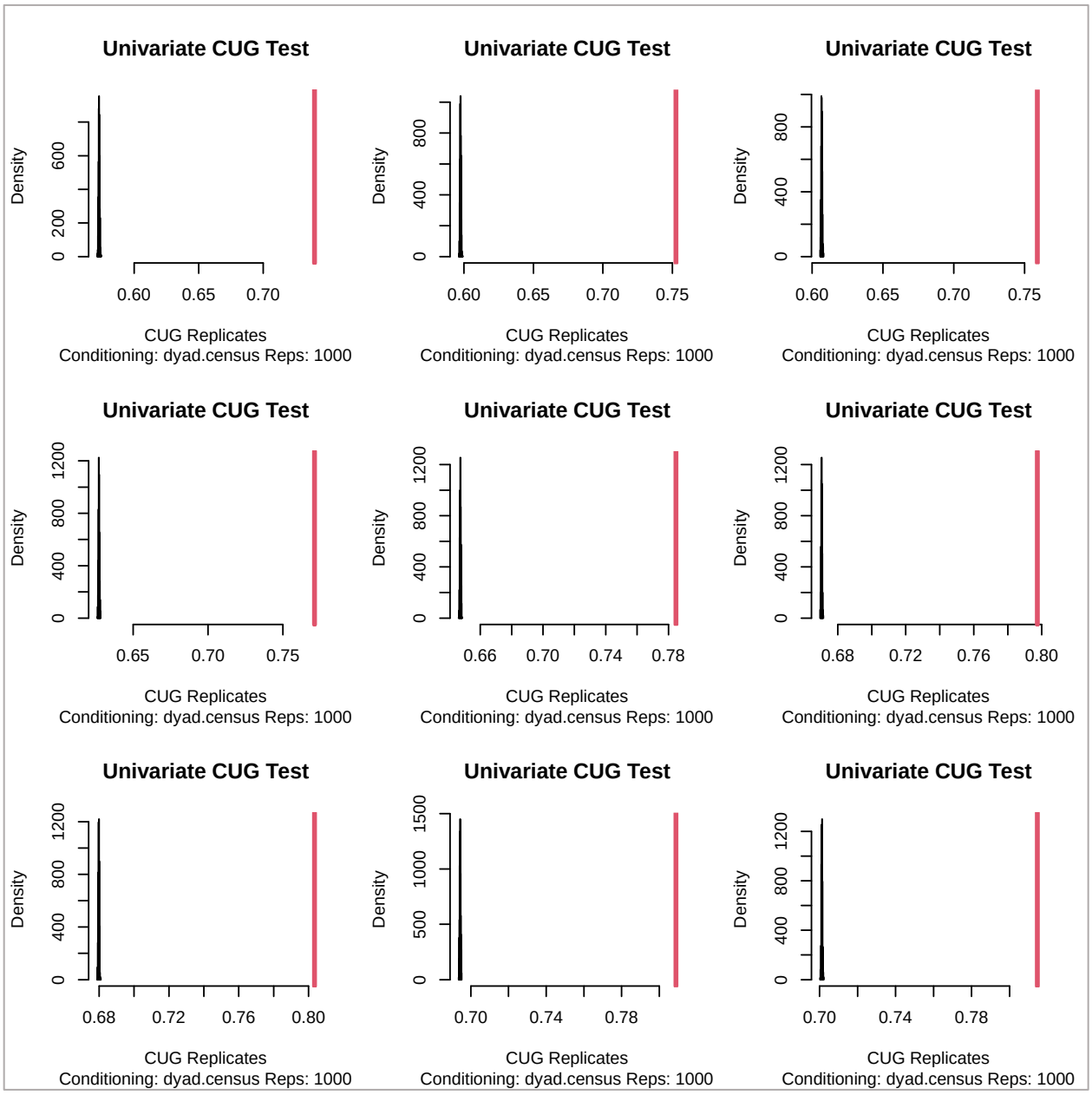


Figure 1.8: *CUG Tests for In-Degree Centralization, 2001 to 2017*

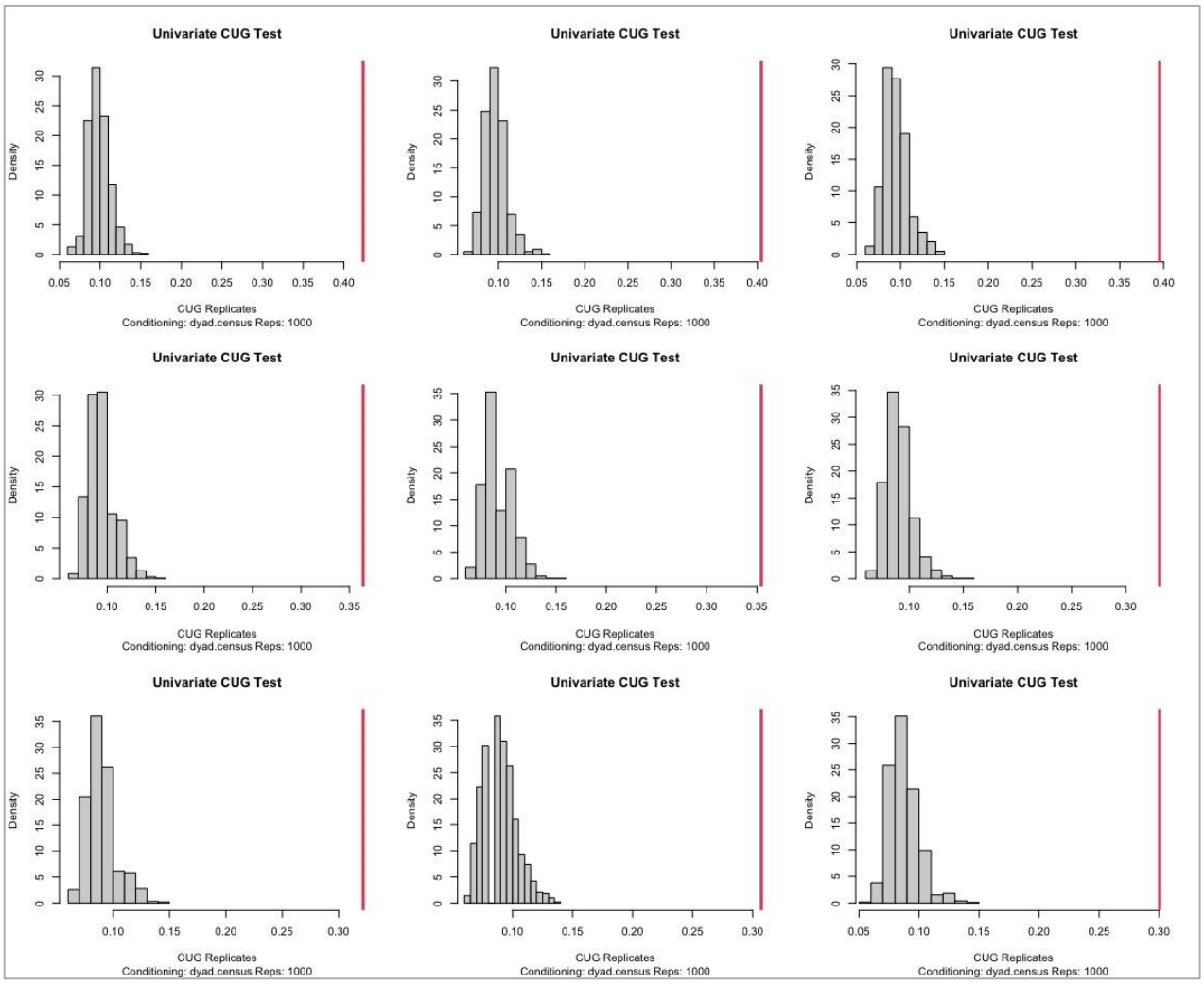
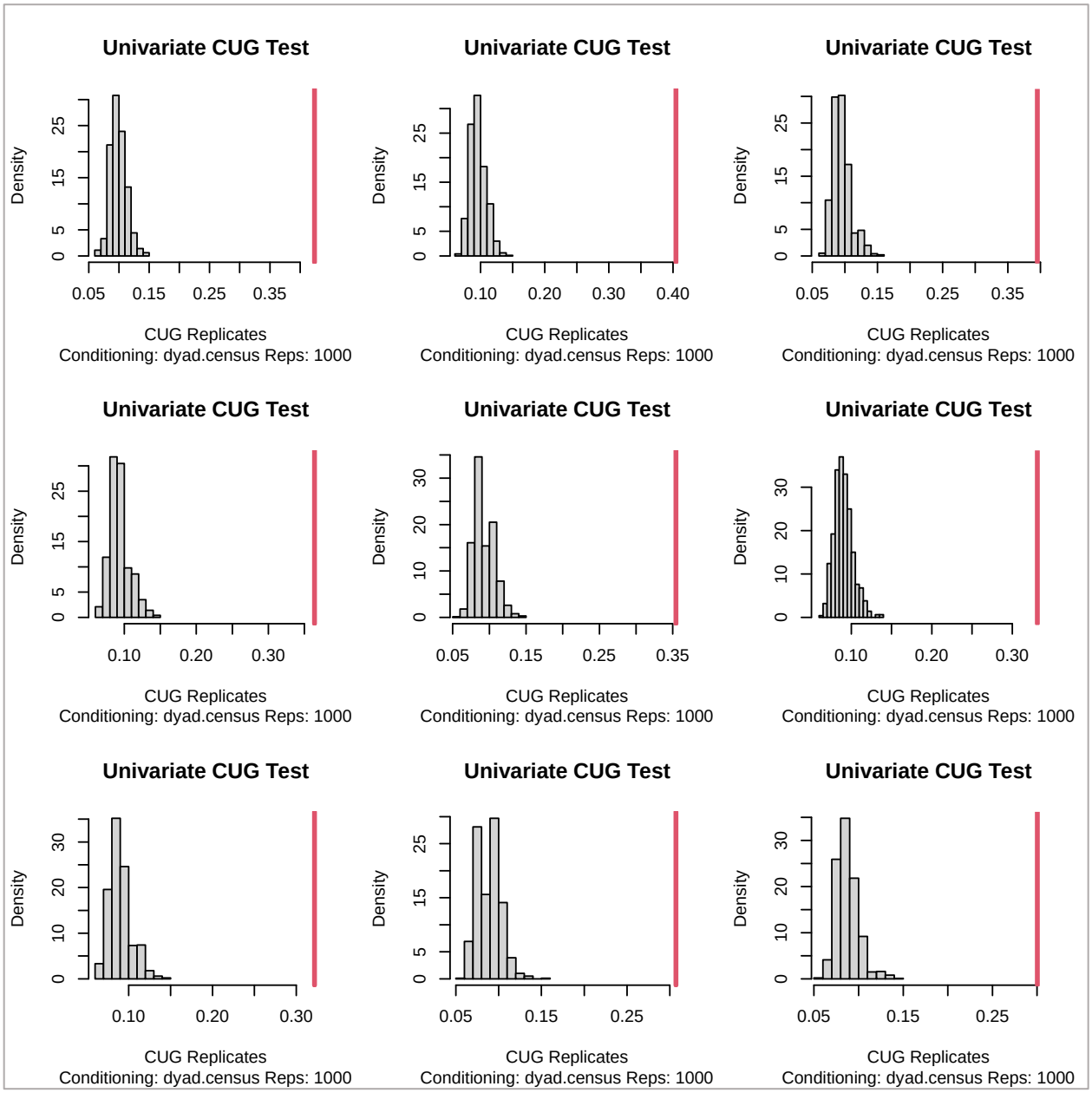


Figure 1.9: *CUG Tests for Out-Degree Centralization, 2001 to 2017*



CHAPTER 2:

The Stability of Structural Inequality in the World Economy: Assessing the Core-Periphery Structure of the Global Trade Network After the 2008-09 Global Economic Crisis

ABSTRACT

How did the 2008-09 global economic crisis affect the hierarchy of the global trade network? Previous research has shown that complex networks of global value chains exhibit a hierarchical, core-periphery structure and that this structure places constraints on non-core countries to mobilize up along the hierarchy. This study examines how the interplay between the 2008-09 crisis and the global trade network's structure mediated the upward mobility of historically periphery and semi-periphery countries along the hierarchy. To achieve this end, I employ a social network analysis to determine if the global trade network continually exhibits a core-periphery structure and assesses whether changes in structural positions over the period of a crisis led to a profound structural transformation within the global trade network. To achieve this end, I employ a Singular Value Decomposition (SVD) analysis to examine international trade data from the International Monetary Fund's *Direction-of-Trade Statistics* from 2001 to 2017. Results show that the global trade network not only exhibited a hierarchical, core-periphery structure, but it was also robust to the impact of the 2008-09 crisis. This is also supported by findings that show only a few countries experienced upward mobility over the period of the crisis. In turn, the results challenge claims that the 2008-09 crisis would give way to profound transformations in the hierarchy of the world economy. More importantly, the findings raise important questions about potential causal mechanisms.

2.1 Introduction

The globalization of trade has embedded many countries into the global trading system and has consequently shaped the social structure of the global trading network. There is considerable

debate as to whether increased trade globalization has had a positive or negative effect on global inequality, particularly between nation-states. Proponents of globalization argue that international trade and investment has reduced trade barriers and generated substantial economic growth in developing countries, which is linked to a reduction in global poverty and has narrowed wealth inequality gaps between nations (Dollar 2002; Wolf 2004). Critics, on the other hand, argue that trade accentuates inequalities between and within nation-states as it places structural constraints on the most marginalized economies to substantively enhance their economic markets (Firebaugh 2000; Galbraith 2012; Wade 2002; Wallerstein 1974). Against this backdrop, few studies have explored the effect of a global economic crisis on the dynamic interplay between trade, globalization, and structural inequality. Specifically, the 2008-09 global economic crisis was viewed as accelerating a "flattening out" of structural inequalities as the influence and prominence of the US and Western Europe was perceived as declining rapidly. For instance, Pieterse (2011) claimed that the 2008- 2009 crisis was part of a global rebalancing process where a "East-South" turn is radically transforming the hierarchy of the world economy. On the other hand, there is broad agreement that the expansion of international trade, especially in the 21st century, and the 2008-09 global economic crisis intensified the spatial unevenness of global capitalism's expansion (Robinson 2015).

I seek to answer two main research questions: *does the structure of the international trade network continually exhibit a hierarchical structure in which some countries occupy dominant positions and possess dominant roles vis-a-vis others?* And secondly, *do patterns of mobility after the crisis suggest profound structural changes in the international trade network or has the relative position of countries remained stable after the crisis?* To answer this question, I conduct the following research strategy. First, to operationalize inequality within the global trade network

I rely on the concept of the core-periphery structure from structural perspectives of economic globalization such as world-systems theory. Second, I apply social network analysis to map the core-periphery structure and assess structural changes over multiple time periods. For my data, I constructed 7 n x n network matrices of international trade from 2001 to 2017 with a sample of 191 countries with the data obtained from the International Monetary Fund's Direction-of-Trade-Statistics.

By observing the trade network before and after the 2008-09 global economic crisis, I can empirically assess how social structures of the global trade network adapted and responded to one of the largest economic downturns in the history of the modern world economy. Overall, findings suggest that the core-periphery structure of the global trading system was relatively stable despite the impact of the crisis. More importantly, the results underscore the constraints that the hierarchical nature of the global trade network places on smaller developing countries.

2.2 Theoretical Framework

2.2.1 The Core-Periphery Structure of the Global Trade Network

Over the past 50 years, increased international trade has expanded and engendered major structural changes within the global trading system. Globalization in the late 20th century has given rise to a global international division of labor that was segmented into a core-periphery structure (Arrighi, Silver, and Brewer 2003; Chase-Dunn and Grimes 1995; Wallerstein 1974). The core and periphery are terms used to describe variation in economic production and political power within the global economic system. Core areas are the main engines of global economic growth due to their modern, technologically advanced production activities that are accompanied by high-skilled and high-waged labor. Peripheral areas primarily export raw materials to core areas and participate in labor-intensive global production activities that generate the least value-

added[3]. Countries in the core are highly interconnected with most other nation-states across the entire global economic system whereas periphery countries, on the other hand, are the least interconnected within the global economic system and mainly depend on their trade relationships with the core. The formation of a "new international division of labor" after regional crises in the 1970s and 1980s entailed large scale shifts in production from historically core regions, mainly from the Global North to peripheral areas throughout the Global South (Dicken 1998; Fröbel, Heinrichs, and Kreye 1980). These shifts manifested themselves in the form of outsourcing and offshoring labor-intensive, low value-added production activities (e.g., manufacturing garments and textiles) by large multinational firms in search of areas where production costs would be lower. These global shifts in production, alongside the reduction of trade barriers throughout the world, facilitated an extraordinary growth in international trade in the late 20th century.

There is considerable debate as to whether the growth in international trade has narrowed global inequalities. While there is some evidence to suggest that trade has led to greater income convergence between rich and poor countries (Wolf 2004), a number of studies have shown that increased trade has led to greater divergence between core and periphery countries (Arrighi et al. 2003; Baddeley 2006; Firebaugh 2000) and stabilizes the core-periphery structure (Mahutga 2006; Mahutga and Smith 2011; Nemeth and Smith 1985). Dicken (Dicken 1998) argues that unequal terms of trade is fundamental to the formation and stability of structural inequalities between dominant core countries and less-dominant periphery countries. The core-periphery structure affords core nations powerful advantages over periphery nations by maintaining trade relations that favor the core while constraining alternative types of trade partnerships for

[3] *Value added* refers to the additional features or economic value that a producer adds to its products before offering them to consumers. Higher added value activities include research and design and marketing whereas lower valued added activities is an activity that requires a lot of resources and labor power, but generates very little value.

periphery nations (Mahutga 2006). Consequently, periphery countries are limited in their capacity to improve their structural position in the hierarchy vis-a-vis their core counterparts (Frank 1966; Frank 1971; Hartmann et al. 2020; Mahutga 2006). Thus, it is expected that these long-term increases in international trade will shape and stabilize a core-periphery structure within the global trade network. To empirically assess the presence and stability of a core-periphery structure, I turn to social network analysis. In the next section, I discuss previous research that applies social network analysis to the study of social structures within international trade networks.

2.2.2 Network Analysis on the Impact of a Crisis on the Global Trade Network

The ideas of the preceding section - that the global trade network is hierarchically organized into a global division of labor and that power asymmetries exist within trade relationships - is suitable for network analysis because of its ability to examine patterns of trade relationships to empirically capture social structures (Mahutga 2006). Numerous studies have applied social network analysis to capture the core-periphery structure within networks of international trade and how the structure affects the economic development of countries (Kick and Davis 2001; Mahutga 2006; Mahutga and Smith 2011; Nemeth and Smith 1985; Smith and Nemeth 1988; Smith and White 1992). However, while there is considerable agreement that trade shapes and reinforces structural inequalities within global trade networks, there is a scant understanding of how or whether a global economic crisis affects this dynamic interplay between structure and inequalities. The 2008-09 crisis precipitated a collapse in global trade that raised questions about the long-term effects on the structure of the global trade network and the world economic system in general. Thus, I aim to examine whether the core-periphery structure underwent profound changes after the 2008-09 crisis or if it remained relatively stable. To

achieve this aim, I turn to the literature that has examined the core-periphery structure after the 2008-09 crisis to provide insights and theoretical expectations for this study.

He and Deem (2010) conducted one of the earliest studies to apply network analysis to assess the hierarchical structure of the global trade network after the 2008-09 crisis. The authors computed a cophenetic correlation coefficient (CCC) of bilateral trade data from 1967 to 2007. The CCC is used to assess how well a particular hierarchical clustering dendrogram correlates with the input data for a clustering. The authors seem fixated on the "hierarchical" interpretation of the declining CCC. Based on a declining CCC over time, the authors argue that the hierarchy of the global trade network has been “flattening” throughout the period of observation, but they also find that brief moments of higher hierarchy follow periods of economic recessions. But a more accurate interpretation would be that through time, the pattern of trade is less well characterized by the ultra-metric distance model (which is what a dendrogram is). Thus, although this study was an initial post-2008-09-crisis attempt at systematically using network analysis to assess the structure of the global trade, their use of average link clustering provides a better measure of clustering and structural dissimilarity than of structural inequality. In addition, the authors operationalize higher levels of hierarchy as a greater tendency amongst countries to trade within a relatively small cluster of structurally similar countries. This is compared to a non-hierarchical structure where countries trade evenly because there are no discernable clusters with high concentration of trade relationships (He and Deem 2010). Thus, the study does not adequately capture a “flattening” of structural inequality within the global trade network, but rather supports the claim that there has been a long-term growth of countries trading evenly across the entire global trade network rather than concentrating strong trade flows within small clusters.

A more recent study by Kostoska et al. (2020) also applied network analysis to commodity trade data from UN Comtrade (up to 2016). Their findings show the existence of a hierarchical core-periphery structure within sectoral international trade networks from 2000 to 2016. Moreover, their findings suggest that the position of core countries at the top of the core-periphery hierarchy remained stable, even after the 2008-09 global economic crisis. However, the reliance on 63 network matrices of specific industries to detect core-periphery structures reduces the size of the sample and narrows our understanding of the entire global trading system. Nevertheless, based on Kostoska et al. (2020) study, there is reason to expect that if the networks of major industries in the world economy exhibit a core-periphery structure, then so will the aggregate global trading network. In addition, there is reason to expect for it to remain stable after the 2008-09 global economic crisis. Thus, in line with Kostoska et al. (2020) findings, I test the following hypotheses:

> H_1: The global trade network will exhibit a core-periphery structure over the period of observation.
>
> H_2: The core-periphery structure of the global trade network will remain stable following the 2008-09 crisis.

The next section discusses the potential impact of the 2008-09 crisis on the smaller developing countries and their capacity to mobilize up the core-periphery hierarchy. Previous studies on the matter will then be used to motivate testable hypotheses on the effect of the crisis on structural mobility within the core-periphery structure.

2.2.3 Upward Mobility in the Wake of the 2008-09

One other area that this study also explores is the potential effect of the 2008-09 global economic crisis on uneven upward mobility along the core-periphery structure. By observing the impact of the 2008-09 crisis on long-term trends in global production and trade, it provides a sociological understanding of the role of macro-level structures on uneven levels of upward

mobility throughout the period of the crisis. Wallerstein (1976) hypothesized that following periods of global economic downturns in the 1970s, there was greater offshoring of mature technologies into the more industrially advanced non-core areas, specifically the "semi-periphery" areas. Mahutga and Smith (2011) conducted a network analysis of international trade networks and confirmed the hypothesis based on their observation of greater upward mobility in the semi-periphery than in the periphery after the 1980s. They also observed greater convergence between the core and semi-periphery but greater divergence between the non-core zones. Kostoska et al. (2020) network analysis of international trade networks after the 2008-09 crisis also finds much more upward mobility amongst historically semi-periphery countries, such as Vietnam, Mexico, and Central and Eastern European countries. In addition, they observe the same group of historically core Global North countries (most notably the US, UK, France, Italy) and China appear in the hierarchy of at least 50 industries before and after the 2008-09 crisis.

However, to gain a greater sense of the 2008-09 crisis' impact on the relationship between structure and upward mobility, it is also important to consider the inherent asymmetries that exist within trade relationships. For instance, certain industries (e.g., garment and textiles, electronics) have undergone shifts in which large multinational corporations retain the R&D aspects of production while offshoring labor-intensive, low value-added production activities to firms in poorer areas (Gereffi 1994, 1999; Gereffi, Fernandez-Stark, and Gereffi 2010; Gereffi and Lee 2016). According to Boyd et al. (2010), these shifts in the global organization of production activities from core to non-core areas manifest into asymmetries within trade relationships. To capture these asymmetries, they differentiate between two types of behaviors within the core-periphery structure: in (import)- and out (export)- coreness. Import-coreness refers to the extent to which a country imports and export-coreness refers to the extent to which a

country exports. In their exploration of the garment industry in 2000, Boyd et al. (2010) observed that historically core countries exhibited greater import-coreness than export-coreness. They also find that a high ranking in import-coreness is a better predictor of a high ranking in symmetrical (i.e., overall) coreness than is a high ranking in export-coreness. Indeed, they find that historically core countries (e.g, The US, UK, Germany, France, and Italy) displayed higher levels of in-coreness while many historically non-core countries with the highest export-coreness did not rank very high in import-coreness. Therefore, if the structural positions of core countries remain stable after the 2008-09 crisis, then it can be expected that higher ranking in import-coreness will remain the most stable and will remain strongly associated with symmetrical coreness.

Therefore, it is worth exploring whether these trends appear in the greater global trade network and how or whether they change after the 2008-09 crisis. However, expectations from previous studies are based on observations of specific industries such as the garment industry in 2001 (Boyd et al. 2010) or the 63 major industries in Kostoska et al. (2020). Thus, when it comes to the entire global trading network, it is not yet clear whether it would exhibit these patterns of asymmetry or extremely divergent ones. These studies, nevertheless, provide a launching point for the study of the 2008-09 crisis's impact on the structure of the global trade network.

For instance, in line with Mahutga and Smith (2011), it would be expected that countries in the middle- and upper-middle tiers of the core-periphery structure (or semi-periphery) are better positioned to experience upward mobility due to their structural proximity to the core after a global economic downturn. Yet, given the GVC literature that highlights the rise of Global South-South trade, the expansion of Chinese and Indian investment in smaller developing countries, and the 2008-09 crisis's devastating impact on the US and Western Europe markets, it

can also be expected that the crisis prompted patterns divergent from previous crises. Specifically, that many periphery countries will experience significant upward mobility over the period of the 2008-09 crisis due to their growing involvement in global trade via Global South-South trade. Whereas in previous crises, smaller developing countries were limited to partnerships with few Global North and historically core countries, the trends of Global South-South trend shows that several smaller developing countries have expanded their trade relationships with larger emerging countries such as China, India, Brazil, and Russia, especially after the 2008-09. However, based on Boyd et al. (2010)'s findings of import, export, and symmetrical coreness in the garment industry in 2000, there is a reasonable expectation that this upward mobility will be confined to only one type of coreness, export-coreness. Hence, it is reasonable to expect that the number of peripheral countries that will experience significantly upward mobility over the period of the crisis will be confined mostly to export-coreness.

Conversely, as historically semi-periphery countries such as China, India, and South Africa gained a greater share of influence within the world economic system throughout the period of the crisis, and their domestic demand for global commodities has grown, it is also reasonable to expect that more widely considered semi-peripheral countries will experience greater upward mobility in import-coreness than their peripheral counterparts. This will, consequently, drive their upward mobility in symmetrical coreness. Therefore, I posit the following hypotheses:

> H_3: Historically core countries will exhibit higher import-coreness than export-coreness before and after the crisis.
>
> H_4: Historically periphery countries will experience greater upward mobility in export-coreness than in import-coreness
>
> H_5: Historically semi-periphery countries will experience greater upward mobility in import-coreness than in export-coreness after the crisis.

H_6: Upward mobility in import-coreness will be strongly associated with upward mobility in symmetrical coreness after the crisis.

2.3 Data

The contribution of this paper is to encompass a greater number of countries to account for the greatest amount of global trade. Therefore, unlike previous studies that focus only on a handful of industries (Kostoska et al. 2020; for example, Mahutga 2006; Mahutga and Smith 2011), I set out to examine the entire global trading system. To construct my network data of international trade, I used publicly available data from the International Monetary Fund's *Direction of Trade Statistics (DOTS)*, which includes bilateral merchandise trade data for various countries and territories over a 1948-2018 period International Monetary Fund (2014). These data are published annually by the International Monetary Fund (IMF) and the World Bank and are distributed as part their *Direction of Trade Statistics Yearbook*. DOTS dataset presents the total value of exports and imports of all member countries of the IMF and is reported in U.S. dollars. Although the data sources give information on both exports and imports, a consensus within the literature is that there is reason to believe that import data are more accurate than export figures (Kim and Shin 2002; Mahutga 2013). In sum, I constructed seven unique trade matrices for 191 countries and across 7 time periods (2001, 2003, 2007, 2009, 2011, 2013, 2017). These multiple matrices will allow for comparison of network properties and structures over time.

To impute missing data, if there was no available import data of Country i from Country j, I relied on the available reported export data. In sum, 191 countries appear in this sample if they either report imports every year, or I relied on export-data from the DOTS data for no more

than one missing year. The full sample is representative of all world regions.[4] In total, I constructed 7 asymmetrical (directed) matrices of international trade from 2001 to 2017. The columns and rows consist of 191 countries, and the cells represent the dollar volume (in $US 100 million) transformed using log+1 transformation. The rows represent export (sender) relationships and columns represent import (receiver) relationships. For the data analysis, I used R Studio and the *Tools for Social Network Analysis* (sna) package developed by Carter T. Butts (2008a).

2.4 Methods

To capture a core-periphery structure in the trade data, I apply a Singular Value Decomposition (SVD) method. In social networks, a discrete core-periphery model consists of two classes of nodes, namely a cohesive subgroup (the core) in which actors are maximally connected to each other and a second subgroup that is minimally connected to each other, but broadly connected to the core, and ties between the two subgraphs are unconstrained (Borgatti and Everett 2000; Boyd, Fitzgerald, and Beck 2006). Studies grounded in world-system theory have expanded upon the core-periphery classification to include groups such as "semi-periphery," "strong periphery," "weak periphery" (Kick and Davis 2001; Mahutga and Smith 2011; Smith and White 1992; Snyder and Kick 1979; Van Rossem 1996). Nevertheless, many of these applications of the core-periphery concepts consider these subgroups as discrete classes. In this paper, the application of SVD treats the core-periphery structure as a continuum where

[4] This presented a challenge as numerous countries gained independence in the early 2000s. To maintain a consistent sample size across multiple time periods, I aggregated the trade flows of recently independent nation-states as part of their former republics' overall trade, a strategy that follows a similar approach by Mahutga (2013). For instance, the republics of Serbia and Montenegro were once a single federal and political unit that officially became the State Union of Serbia and Montenegro in 2003. In 2006, Montenegro seceded from the union which led to the recognition of Serbia and Montenegro as independent states. In addition, Kosovo officially declared its independence from Serbia in 2008. In turn, I aggregated the trade data of Kosovo, Serbia, and Montenegro and categorized them under the country label of "Serbia and Montenegro," the name of its former republic, for all time periods under investigation.

actors (or countries, in this instance) with higher values of coreness tend to be highly connected with each other, while those with low values, periphery actors, tend to be sparsely interconnected with each other. I then empirically verify that the observed core-periphery structure in the data is far from what would be expected given certain network properties.

SVD is a method for identifying and ordering dimensions along which data points exhibit the most variation to the least amount. This method takes a high-dimensional, highly variable set of data points and reduces it to a lower dimensional space that exposes the substructure of the original data more clearly and then orders it from highest amount of variation explained to the least. From the SVD analysis, we expect to observe a tendency for the global trade network to conform to a core-periphery structure. This can be detected by observing a tendency for historically "core" countries to have higher levels of connectivity with all other countries throughout our period of observation. A SVD analysis is suitable for studying core-periphery structures in social networks because of its capability to analyze the core-periphery structure as a continuum rather than a discrete structure (i.e., core and periphery). However, to apply an SVD method requires a matrix where the diagonals contain relevant information. Most, if not all, international trade network data do not contain any information in the diagonals since a country cannot trade with itself. To overcome this limitation, I add relevant information into the diagonals by applying a similar strategy by Boyd et al. (2010) to approximate data matrices with an expression analogous to, but distinct from, an SVD matrix.

Computationally, I conduct a SVD analysis on the global trade network at each time point. The the *singular value decomposition* of a real *m* by *n* matrix *A* of rank *r* is a triple of matrices (U, D, V) such that

$$A = UDV^t$$

where U and V are matrices containing eigenvectors, and D is a r by r diagonal matrix of singular values. SVD decomposes the information contained in a data matrix into three matrices: a N − 1 dimensional U matrix summarizing the information in the rows, a $N - 1$ dimensional V matrix that summarizes the information in the columns, and a r by r diagonal matrix D that summarizes the information in the row and columns, U and V, respectively. D contains elements d_i that are called *singular values* and are ordered ($d_1 \geq \cdots \geq d_r > 0$) from the highest to lowest amount of variance explained by each dimension of U and V. From the U and V matrices that contain eigenvectors, I use the first eigenvector as those are associated with the largest singular value. The derived eigenvectors will be my measures of coreness. Therefore, from the SVD I can assign coordinates of in- (import)- coreness based on the derived eigenvectors from the V matrix, and out-(export)- coreness from the eigenvectors from the U matrix.

The singular values from D are then used to detect a core-periphery structure by finding the percent sum of squares on each dimension and observing the amount of variance explained by the first dimension d_1 relative to the subsequent seven dimensions ($d_1 \geq d_2 \ldots d_8$). In addition, the approximation of the diagonals for our trade matrices produces a vector W that captures the symmetrical coreness of each actor. The W vector represents the marginal value of each country's exports and imports; thus, it takes each country's total exports and total imports into account. To be more precise, the W summarizes the information in the row totals and column totals in a n by n data matrix. Both out- and in-coreness measures range from 0 to 1.00 and symmetrical coreness ranges from 100 to 0 with higher scores indicating higher coreness status within each type of measure. To make the out- and in-coreness measures easier to interpret I scaled these measures by 100 for each of the U and V matrices. To summarize, from the SVD

application on the data I derived three vectors - V, U, and W - that represent import-, export-, and symmetrical coreness of each country in each period of observation.

Upward mobility was assessed in two ways. The first was as the change in rank ordered positions between the pre-crisis period (2007) and the post-crisis period (2011). A goal of this study was to explore how the crisis affected not only the structural configuration of the global trade network, but also the opportunities or lack thereof afforded smaller developing countries to mobilize up the hierarchy. To better observe these trends across time I compared the structure prior to the crisis and immediately after the crisis rather than solely during the crisis. Therefore, to assess the impact of the 2008-09 crisis on upward mobility, I measured the change in rank score from 2007 to 2011.

An advantage of using rank ordering is that it reduces these complex measures of coreness to a sequence of ordinal numbers that can approximate a rank of countries and then sort them in descending order with larger values indicating higher coreness to lower values that indicate lower coreness (or more periphery-like). The added leverage is that it can better obtain a simplified yet substantive measure of structural mobility. The rank order will be derived from the assigned coordinates of each country from each vector V, U, and W and will rank countries from highest (most coreness) to lowest (least coreness). For instance, out of 191 countries, a core country such as the US would rank "191" whereas a historically periphery country such as El Salvador would be ranked closer to 1. Thus, structural mobility is measured as a change score that is computed as the difference in rank order position in t_2 minus the rank score in time t_1. The change score will then be sorted in descending order from largest to smallest to observe which countries experienced the greatest *positive* change in rank order.

The second approach to empirically study significant upward mobility was to empirically verify whether the positive change in rank score (a detection of upward mobility) from 2007 to 2011 led to a level of coreness that was significantly greater than the global average in 2011. Conceptually, this will capture the change in distance between a country and the center of the core group over the period of the crisis, and this procedure will be conducted for both import- and export-coreness measures. For example, if *Country A* experienced a change in rank score of +10 in import-coreness from 2007 to 2011, I then compared their import-coreness score in 2011 to the global average of import-coreness for that year. A one-tailed t-test of significance ($\alpha = 0.05$) is then used to verify if *Country A's* import-coreness in 2011 is significantly greater than the global average of import coreness for 2011. If so, then it can be concluded that country *A* experienced significant upward mobility over the period of the crisis.

2.4.1 Conditional Uniform Graph (GUG) Test for Core-Periphery Structure

Null models - In the context of core-periphery structures in trade networks, a null hypothesis (null model) addresses an expectation that the core-periphery structure that is observed is drawn from a single distribution, and that any distinguishable pattern drawn from the data arose from random sampling processes. Using conditional uniform graph (GUG) tests, I empirically determine the discrepancy between observed core-periphery structures versus those that would be obtained by random chance. More precisely, CUG tests examine the extent to which higher-order features of a network (e.g., reciprocity, transitivity, centralization) are influenced by lower-order features (e.g., size and density) that can vary across multiple network populations (Anderson, Butts, and Carley 1999; Butts 2006; Faust 2007). CUG values are estimated using Monte Carlo simulation procedures that then provide a baseline distribution to test a null model. Such distribution is constructed from 100 random graphs each with the same

number of nodes as the observed network (N = 191) and the same value of the graph properties on which the distribution is conditioned (Holland and Leinhardt 1974; Wasserman and Faust 1994). For each random graph the proportion of variance on the first dimension of the SVD is calculated and the distribution of these values is the baseline distribution to compare the observed core-periphery structure. The proportion of variance on the first dimension of the SVD of the observed graph is compared to this baseline distribution. The goal is to determine whether the observed core-periphery structure is "typical" of networks with similar network characteristics.

As part of the procedure, it is also necessary to compute the proportion of results in the random graphs that are less than or equal to the observed result ($P(X \leq Obs)$) and the proportion of results in the random graphs that are greater than or equal to the observed result ($P(X \geq Obs)$), and these are analogous to randomized p-values (see Butts 2011 for mathematical explanation). More precisely, this formulation measures the probability of observing a higher-order feature of a network given some lower-order property within the same network. Observations far from the baseline distribution are significantly far from random chance and are not solely attributable to underlying low-order properties within the network.

For this study, I considered a null model for examining the core-periphery structure in the trade network at each point in time and conditioning on the U|MAN distribution, or dyad census, of the observed network in each year of observation. However, since the dyad census is applicable to only dichotomous (0/1) network data, I dichotomized the valued trade relations within the global trade network. To dichotomize, I considered only trade relations that generated an annual volume of trade of more than or equal to $100 US million in each year, and anything below that threshold was considered as an "absence of a trade tie". For the core-periphery CUG

test, the alternative hypothesis is that the core-periphery structure that is observed in the data is not the result of low-order properties, or "random chance."

To start, I assumed all countries in the global trade network had equal probability to be involved in mutual, asymmetric, and null dyads. Following Holland and Leinhardt (1977) I drew a dyad census that considered each dyad in a directed graph to be in one of three states: the null state (empty dyad), a complete or mutual state ($a \longleftrightarrow b$), and either of two asymmetrical ties ($a \rightarrow b$ or $a \leftarrow b$). The dyad census classified each dyad into either the mutual, asymmetric, or null categories, counting the number of each within the observed network. This dyad classification for each year was then used to condition the random graphs. I then generated 100 random graphs that were conditioned on the observed U|MAN distribution mentioned previously. These random graphs then underwent a similar SVD analysis as the observed network to extract their 1st dimensions with the amount of variance they each explained, which then provided a reference distribution as the baseline for the null hypothesis (Butts 2008a). In the following section, I discuss the results and divide sections by the hypotheses I presented earlier.

2.5 Results

2.5.1 The Core-Periphery Structure and its Stability

Figure 2.1 shows the percent of variation explained by the first eight dimensions of D for each time-period compared. The amount of variation explained by the first dimension d_1 is compared to the subsequent seven dimensions. The X and Y axis correspond to the dimension and the percent of variation that each of the seven dimensions explains compared to the other dimensions. In each time-period the first dimension d_1 contained the highest percentage of variance explained and was significantly larger than the subsequent seven dimensions. Figure 2.2 shows the amount of variation explained by the first dimension increasing monotonically from

82.08 percent in 2001 to 87.14 percent in 2017. This is consistent with previous research that apply similar methodological approaches and find that high variation explained by the first dimension will correspond with a core-periphery structure in the data (Borgatti and Everett 2000; Lloyd, Mahutga, and Leeuw 2009; Mahutga 2006; Mahutga and Smith 2011).

Figure 2.3 displays the CUG test plots that compares the observed explained variation in the first dimension across each time-period (red line) to a randomly generated distribution (reps = 100) of 1st dimensions along with their explained variation. Moreover, in all years, the proportion of random cases greater than or equal to the observed core-periphery was 0.0 and the proportion of random cases less than or equal to the observed core-periphery was 1.0. Therefore, the observed percent variance explained by the first dimension in each time-period is more pronounced than what would be expected given the dyad census of the observed network and the probability of observing this pattern because of lower-order properties is very unlikely. Thus, the CUG tests show that there is a pronounced core-periphery structure in each year that cannot be accounted for by the dyad census in the observed network.

To assess the stability of the core-periphery structure, I computed Pearson's r correlation coefficients on each of the V, U, and W vectors across each time-period to examine inter-year correlations of each coreness measure. High and positive correlations will detect strong long-term structural stability in the data whereas weak and statistically non-significant coefficients will detect less structural stability (Mahutga 2006).

***Figure 2.1**: Percent of Variance Explained in First 8 Dimensions*

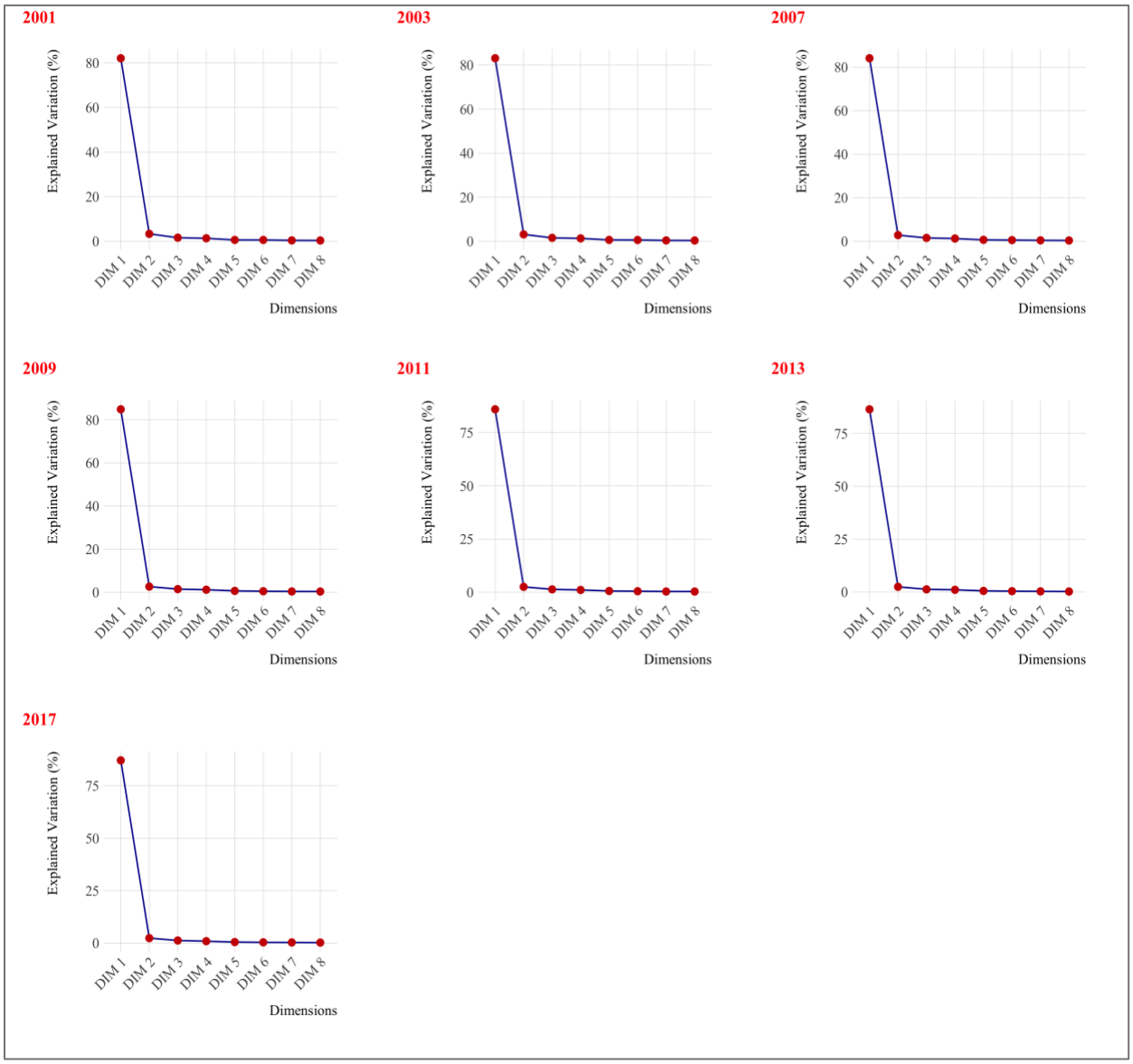
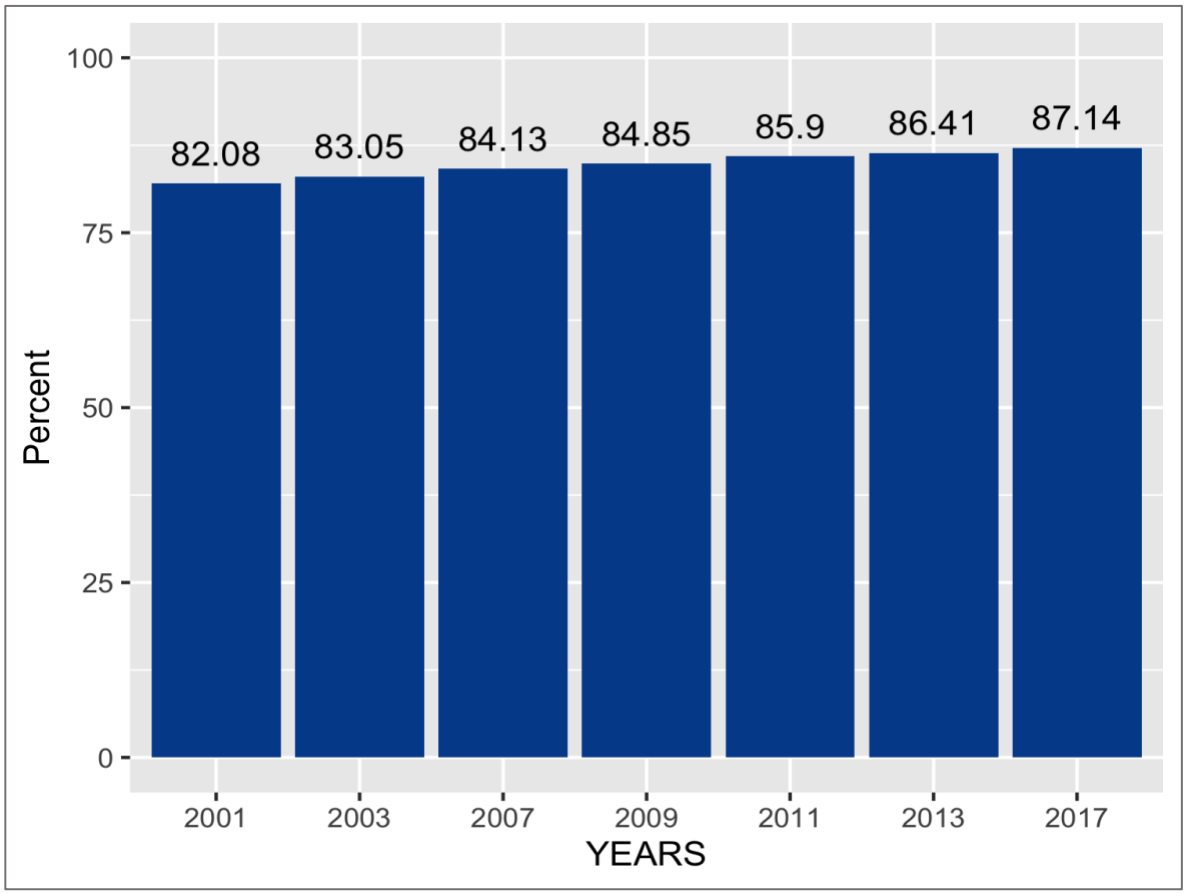


Figure 2.2: *Explained Variation by First Dimension Across time*



Tables 2.1, 2.2, and 2.3 display the correlation matrices of each type coreness measure and indicate strong positive correlation over time. In each correlation matrix, most correlation coefficients are near +1.0 ($r \geq 0.9$), a near perfect positive correlation, and are all statistically significant at a $p < 0.0001$. This implies that countries with high coreness in one time-period displayed high coreness over time and this was consistent across all three types of coreness. This is consistent with Mahutga's (2006) findings that inter-year correlations of structural position are indicative of structural stability over time. Both figures 2.1 and 2.2 display an extremely large amount of variation that is explained in the first dimension of each time-period and fulfills the expectation of a core-periphery structure in the trade data. Additionally, the Pearson r correlation coefficients presented in tables 2.1, 2.2, and 2.3 display strong and statistically significant

correlation within each type of coreness measure across time, thereby providing evidence of structural stability. More importantly, the core-periphery structure appears to remain stable despite the impact of the 2008-09 crisis on global trade. These results provide evidence against claims that the 2008-09 global economic crisis would radically transform the hierarchical structure of the global trade network.

Furthermore, the CUG tests in figure 2.3 illustrate that the core-periphery structures observed in the data are far from what would be expected given the dyad census of the observed trade network and thus far from random chance. Overall, these findings detect a tendency for higher stability at the top of the structure in each type of coreness and suggest further that these structural positions have remained stable throughout the first 17 years of the 20th century. Together these findings provide robust evidence that the global trade network continues to operate within the confines of a hierarchical, core-periphery structure. The next sections explore the variation in stability and mobility within different types of coreness.

Table 2.1: *Pearson Correlation Coefficients of Import-Coreness, 2001-2017*

	2001	2003	2007	2009	2011	2013
2001						
2003	0.949****					
2007	0.947****	0.942****				
2009	0.938****	0.934****	0.991****			
2011	0.929****	0.926****	0.978****	0.987****		
2013	0.928****	0.926****	0.976****	0.986****	0.984****	
2017	0.913****	0.911****	0.965****	0.977****	0.976****	0.981****

Note: **** Correlation is significant at $p < 0.001$; two-tailed test

***Table 2.2**: Pearson Correlation Coefficients of Export-Coreness, 2001-2017*

	2001	2003	2007	2009	2011	2013
2001						
2003	0.997****					
2007	0.992****	0.996****				
2009	0.987****	0.992****	0.997****			
2011	0.983****	0.988****	0.994****	0.997****		
2013	0.978****	0.984****	0.991****	0.995****	0.998****	
2017	0.972****	0.978****	0.986****	0.990****	0.993****	0.996****

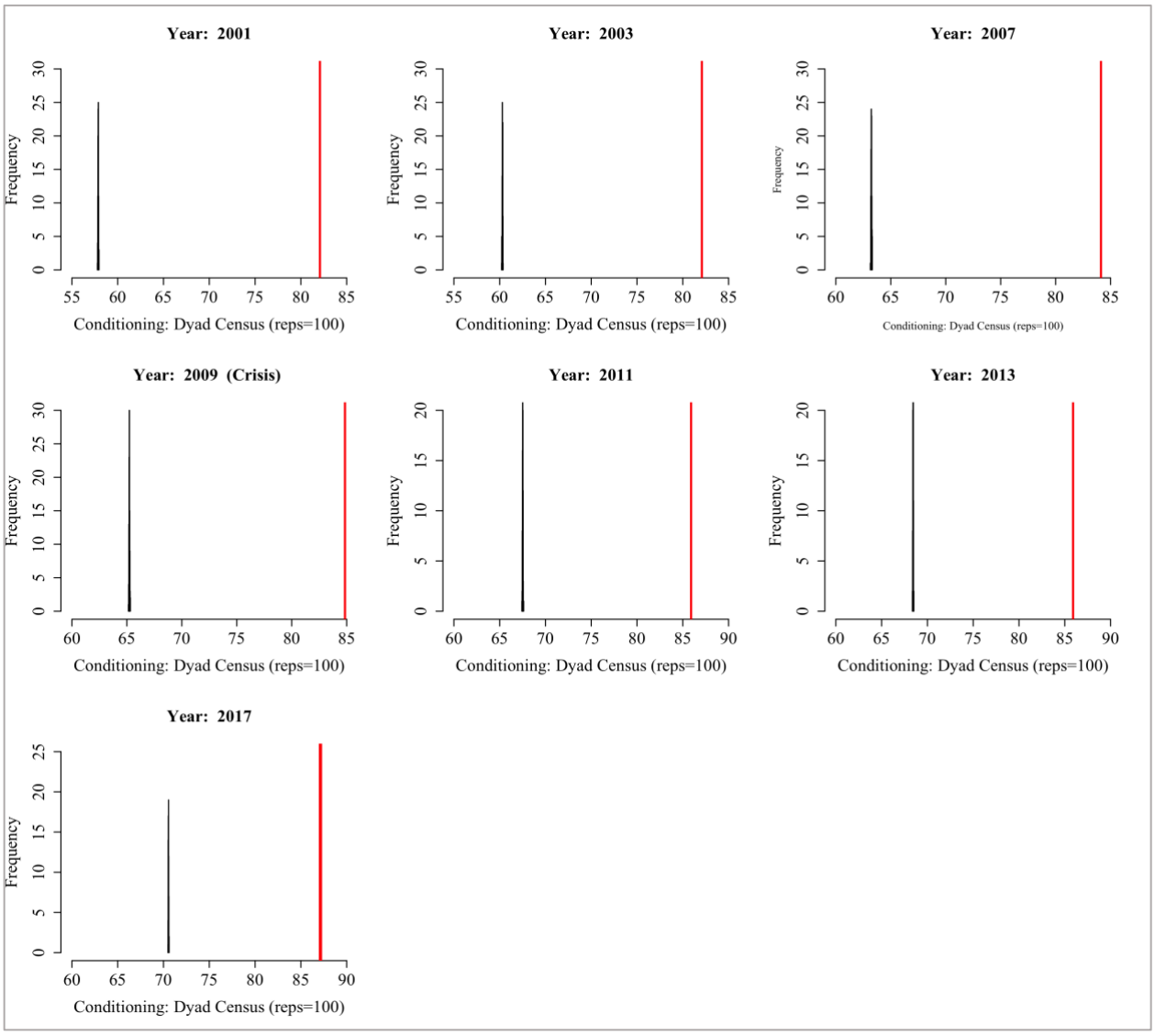
Note: **** Correlation is significant at $p < 0.001$; two-tailed test

***Table 2.3:** Pearson Correlation Coefficients of Symmetrical Coreness, 2001-2017*

	2001	2003	2007	2009	2011	2013
2001						
2003	0.992****					
2007	0.985****	0.989****				
2009	0.980****	0.984****	0.996****			
2011	0.974****	0.979****	0.992****	0.998****		
2013	0.971****	0.975****	0.987****	0.993****	0.995****	
2017	0.964****	0.968****	0.985****	0.992****	0.994****	0.993****

Note: **** Correlation is significant at $p < 0.001$; two-tailed test

Figure 2.3: *CUG Test Plots for Core-Periphery Structure, 2001-2017*



2.5.2 Export- and Import-Coreness Throughout the Period of the Crisis, From 2007 to 2011

Figures 2.4 and 2.5 plot the export-coreness (vertical axis) and import-coreness (horizontal axis) of each country for the global trade network in 2007 and 2011, respectively. These plots compare the association between export- and import-coreness in 2007 (pre-crisis period) and 2011 (post-crisis period). In both plots, the countries with both highest import- and export-coreness (top right of the graph) are the most "core-like" and those with the lowest

measures of coreness (lower left of the graph) are the least core-like. This provides an intuitive sense that the coordinates from the SVD analysis not only correspond to a measure of coreness but effectively capture the entire core-periphery structure. Tables 2.9, 2.10, and 2.11 (included in "Supplemental Tables" section) display the information on the position of the top 100 countries in import-, export-, and symmetrical coreness scores that were derived from the SVD analysis, respectively. [5] They are sorted in descending order by their rank order position in 2011 along with their change in rank order from 2007 to 2011 (far right column). Thus, the SVD analysis gives a sense of a country's structural position relative to other countries in the network while the rank order provides a clearer picture of structural position and mobility over the period of the crisis.

First, the findings indicate that core countries such as the US exhibited higher *export-coreness* than *import-coreness* before and after the crisis. This pattern does not solely hold for the US, but other widely accepted "core" countries as well, such as Germany, France, Italy, Netherlands, and the UK. Patterns also show that Global South countries that are also widely considered "semi-peripheral" such as China, South Korea, India, Brazil, and Indonesia, exhibited higher import-coreness than export-coreness.[6] Second, as shown in tables 2.9, 2.10, and 2.11 nine of the top ten countries in both import- and export-coreness are also in the top ten in symmetrical coreness in both 2007 and 2011 (China, United States, Germany, France, Italy, Netherlands, United Kingdom, Japan, India). The two countries not in the top ten of all three coreness types are South Korea (top ten in export-coreness only) and Spain (top ten in import-corensss and symmetrical coreness, but not in export-coreness). Also, the placement of countries

[5] Due to the high number of countries, I include the full version of these tables in Appendix B.
[6] For a more standard reference of world-system classification of "historically core," "historically semi-periphery," and "historically periphery" countries, I rely on Lloyd et al (2009), Mahutga (2006), Mahutga and Smith's (2010), Van Rossem (1996) empirical classifications

in the highest positions are almost identical across all coreness types in 2011, but there is a noticeable change in leadership. Over the period of the crisis, China overtook the US and Germany to become the leader in symmetrical coreness (as shown in table 2.11). Also, during this same period, China moved up to the second highest rank in import-coreness while maintaining the highest rank in export-coreness (as shown in tables 2.9 and 2.10).

From these findings, three conjectures about the hierarchy of the core-periphery structure can be suggested. First, membership at the very top of the hierarchy remained nearly unchanged, which indicates that the structural position of these countries was relatively robust to the impact of the crisis, and this is also supported by the Pearson's r correlation coefficients in tables 2.1, 2.2, and 2.3 which show stable structural positions across all three dimensions of coreness. Nevertheless, there were minor yet noticeable changes in the placement of countries within the hierarchy of the core periphery structure. Most notably, China's upward mobility in import-coreness was associated with an increase in rank order in symmetrical coreness. China's upward mobility to the top position in symmetrical coreness is perhaps attributed to their upward mobility in import-coreness as well as their stability as the leader in export-corenesss throughout the period of the crisis.

This is related to the second conjecture which is that China, India, and South Korea's high placement in the export- and import hierarchy after the 2008-09 crisis is indicative of their long-term emergence as major players in the world economic system. Historically, these three countries have been major recipients of offshoring and outsourcing, but their rapid economic development over the past four decades has expanded the extraordinary economic growth of their very large domestic markets, thereby fueled their rise as major recipients of global imports while they remained major global exporters (Farooki and Kaplinsky 2010).

***Figure 2.4**: Core-Periphery Plot for Global Trade Network, 2007*

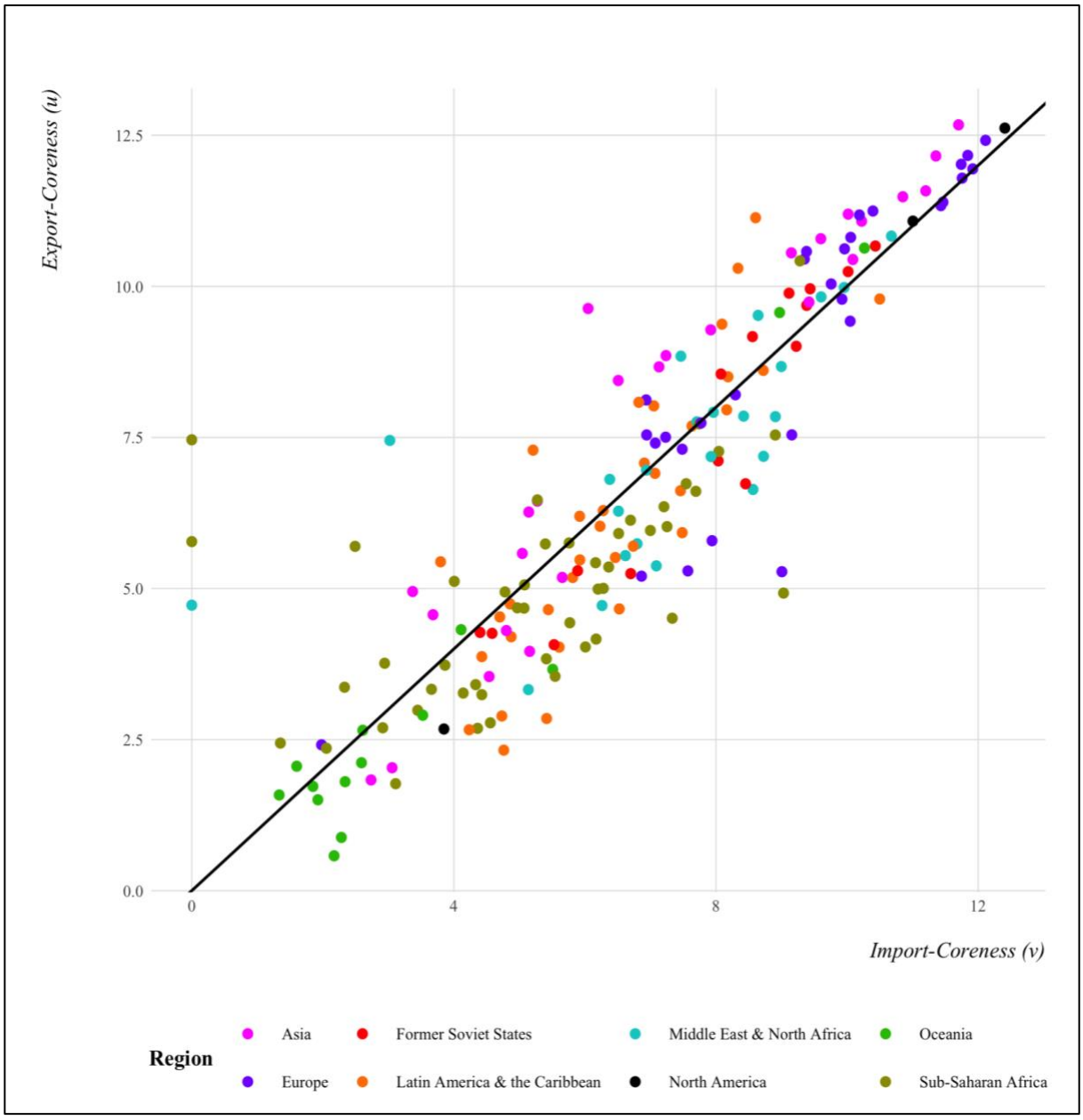
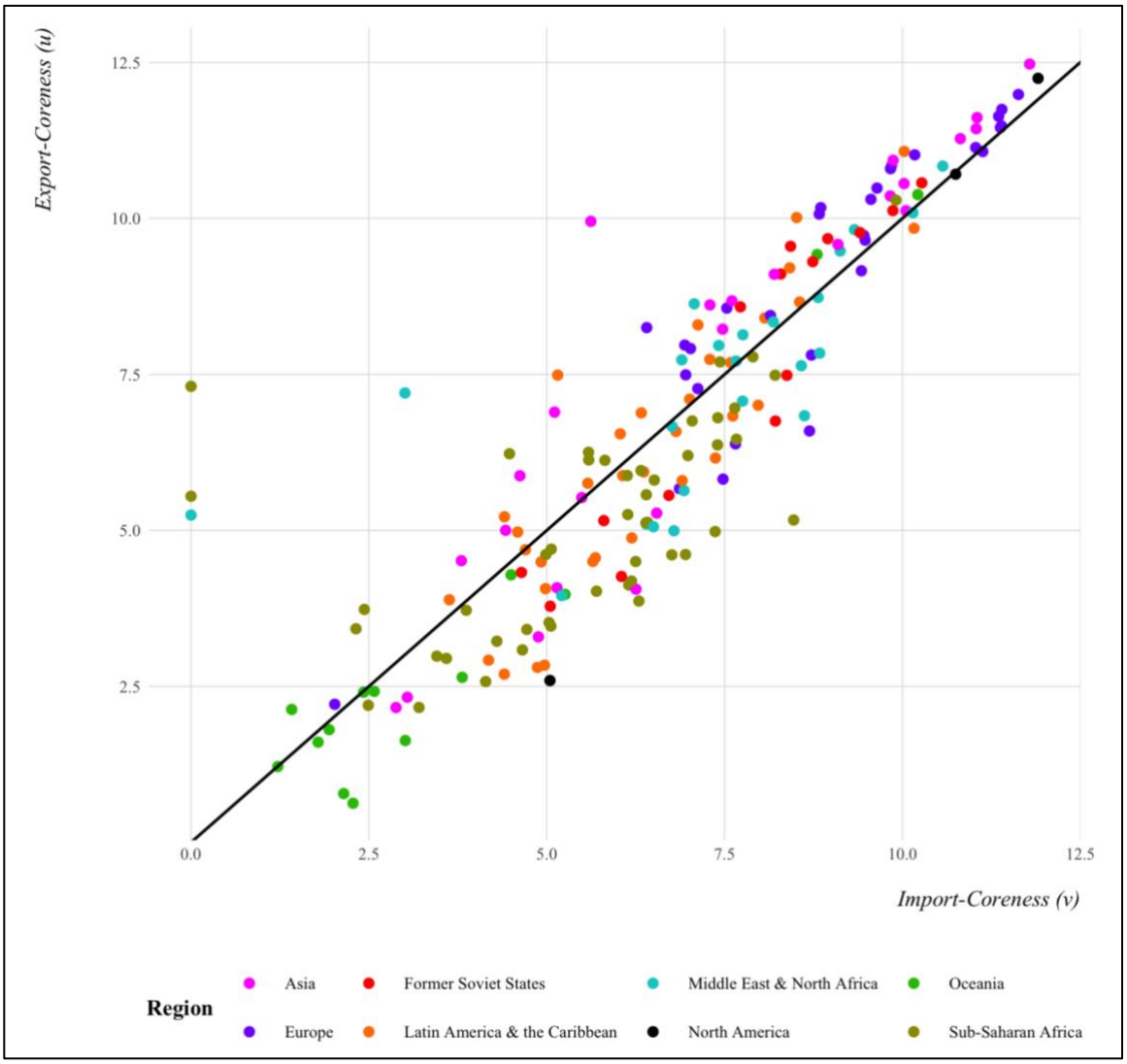


Figure 2.5: *Core-Periphery Plot for Global Trade Network, 2011*



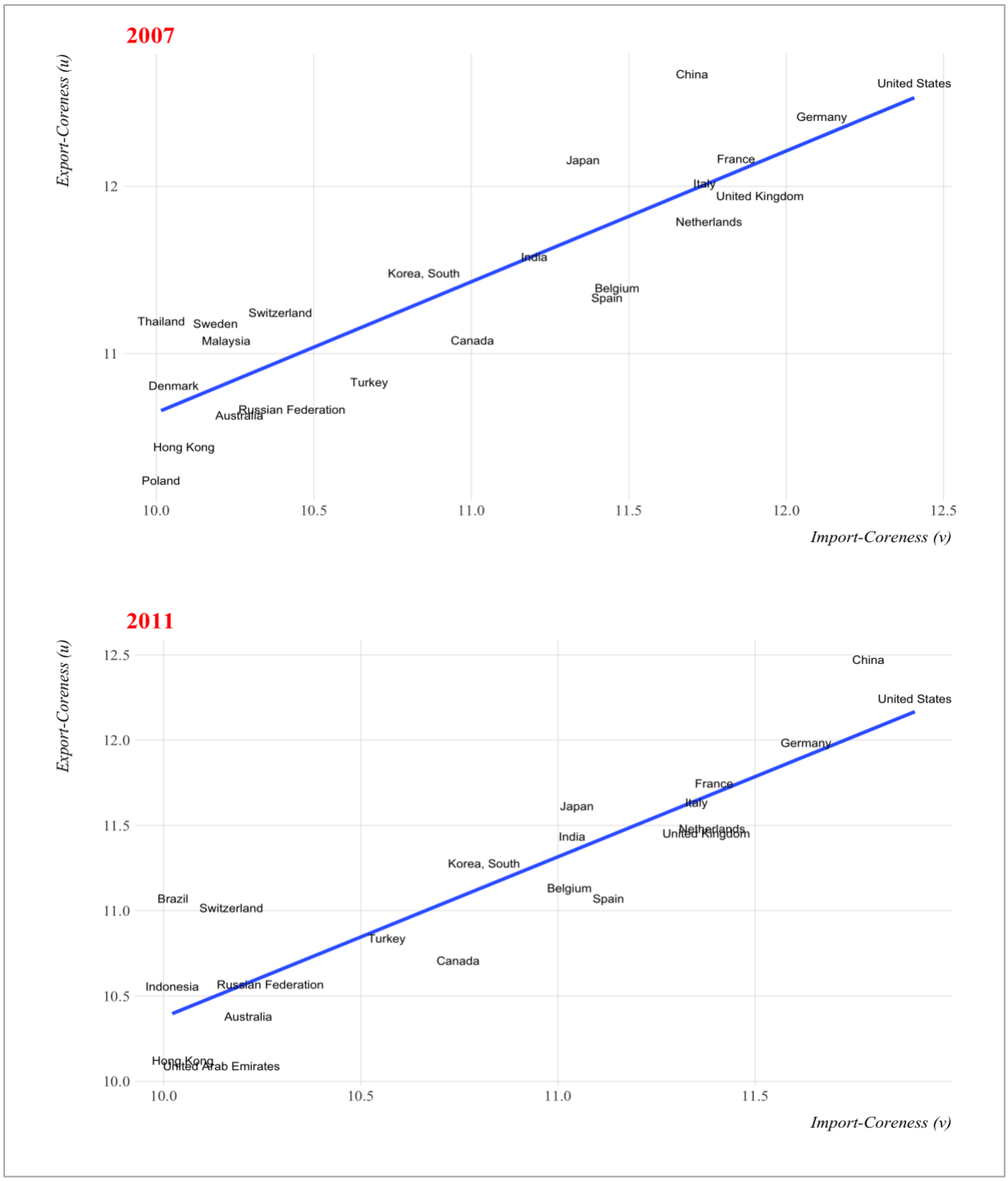
Furthermore, China and India's rise as major exporters has led to a burgeoning demand for commodities as inputs for their manufacturing sector and to fuel the rapid urbanization, which proliferated after the 2008-09 crisis (Gereffi 2014; Kaplinsky and Messner 2008; Kaplinsky, Terheggen, and Tijaja 2011). Nevertheless, there was little regional diversification within the very top of the hierarchy in 2011 as all the countries in the top ten in all three categories are from Asia and Europe (except for the US).

The third conjecture is that the evidence does not support the claims of hypothesis 3 which expected historically core countries (i.e., the US, Western European nations, Japan) to display higher import-coreness than export-coreness after the crisis. However, countries at highest end of coreness are almost all above the 45-degree line. In contrast, it appears as though most mid-range countries are below the line. As shown in figures 2.4 and 2.5, in both years many countries do not fall on or relatively near the 45-degree line from bottom left to top right, which would indicate relatively similar import- and export-coreness. Instead, there are huge differences in the import- and export-coreness scores for many countries, and some of these differences are rather large. These differences appear rather large as we go to the lower-tiers of the core-periphery structure, but these differences appear less extreme in the highest tier of the structure. Figure 6 displays the import- and coreness score of the top 20 countries in 2007 and 2011, respectively, and illustrate that historically core countries exhibit higher export-coreness than import-coreness in 2007 and 2011. In should be noted still that the crisis does appear to have pulled the most core-like countries closer to the 45-degree line, which indicates a narrower difference between their import- and export-coreness scores.

To summarize these findings, I highlight the following trends that do not support the claims of hypothesis 3, but nevertheless yield substantive results. First, historically core countries exhibited higher export-coreness than import-coreness over the period of the crisis. This implies that despite the impact of the 2008-09 crisis on the largest markets such as the US and the UK, the major economies of the world remained central players in global exports, which is a standard measure of global output. Despite expectations that the impact of the crisis would undermine the leadership of these countries within the hierarchy of the world economy (for instance Pieterse (2011)), their sustained presence within the top of the hierarchy challenges

these expectations. The second claim is that China and India, nevertheless, entered the core of the global trade network during the period of the crisis. The rise of China into the very top of the global trade network during the crisis was expected given their historical rise as a major center of global trade activity. To further assess the impact of the 2008-09 crisis on upward mobility, I assessed the structural mobility over the period of the crisis within import- and export-coreness, which is discussed in the next section.

***Figure 2.6**: Top Countries of Core-Periphery Structure, 2007 and 2011*



2.5.3 The Impact of the 2008-09 Crisis on Structural Mobility

Tables 2.5 and 2.6 list the top 30 countries with highest numerical change in rank score in import- and export-coreness from 2007 to 2011, respectively, sorted by the largest positive

change in rank score to the lowest (shown in the far-right column in each). As mentioned above, ranking countries by their coreness score is a clear and concise indicator of structural position and positional change. However, a more systematic measure of significant upward mobility, especially for peripheral countries, is to determine whether their relatively large change in rank order from 2007 to 2011 was associated with having a coreness score that was substantially higher than the global average in 2011.

For instance, while Mauritania and Sudan had some of highest positive change in rank score for import-coreness (+37) and export-coreness (+51), respectively, their substantially large change in rank order position was not associated with a higher-than-average coreness score in 2011. And, as I also mentioned earlier, a one-tailed t-test of significance ($\alpha = 0.05$) was used to empirically test whether a country's coreness score was significantly greater than the global average, and table 2.4 provides descriptive statistics of each coreness measure for reference. As shown in tables 2.5 and 2.6, there is greater variability in rank order change within import-coreness than in export-coreness (far right column), respectively. For instance, in table 2.5, the change in rank order position in import-coreness ranges from 6 to 77, whereas change in export-coreness ranges from 5 to 51 (see table 2.6).

Table 2.4 *Descriptive Statistics of Import-, Export-, and Symmetrical Coreness Measures*

	Mean	Median	Max	Min	Std Dev	Std Error	95% CI Lower	95% CI Upper
2007								
Import	6.75	6.757	12.128	0	2.6	0.19	6.38	7.12
Export	6.61	6.202	12.634	0.561	2.96	0.21	6.2	7.02
Symmetrical	11.14	7.773	38.89	0	9.53	0.69	9.78	12.5
2011								
Import	6.77	6.891	11.806	0	2.56	0.19	6.4	7.14
Export	6.67	6.495	12.431	0.807	2.81	0.2	6.28	7.06
Symmetrical	11.69	8.707	38.629	0	9.45	0.68	10.35	13.03

With regards to import-coreness (shown in table 2.5), eight of the top 30 countries with the largest positive change in rank order position had an import-coreness score that was greater than the global average in 2007, and in 2011 that number grew to eleven. Specifically, three historically periphery countries experienced a large positive change in their rank score that was also associated with noticeable upward mobility in 2011: Mozambique, Bahrain, and Uruguay. In other words, their import-coreness scores were less than the global average in 2007, but their import-coreness scores increased in 2011 to a level greater than the global average.

The eight countries that exhibited higher than average import-coreness in both years *and* experienced a large positive change in their rank scores from 2007 to 2011 were more typical of semi-periphery countries: Singapore, Nigeria, Sri Lanka, South Africa, Ecuador, Colombia, Argentina, and Jordan. Subsequently, of these eight countries, three large semi-periphery countries entered the category of top 30 countries with the highest import-coreness (South Africa, Singapore, and Indonesia) over the period of the crisis. Their convergence with the very top of the hierarchy is indicative of their historical growth as some of the largest emerging economies of the world economy. In addition, previous studies show that the national economies of these countries were relatively stable throughout the crisis and remained major importers of goods and services during this period (Carmody 2017a).

As for export-coreness, table 6 displays the list of the top 30 countries who had the largest positive change in rank score in export-coreness. Nine of the 30 countries had an export-coreness score that was significantly greater than the global average in 2011, and eight of those nine also had significantly higher than average export-coreness scores in the previous period (Qatar, Oman, Estonia, Belarus, Lithuania, Saudi Arabia, the Czech Republic, and Singapore). Cambodia is the only periphery country who experienced significant upward mobility from 2007

to 2011 in export-coreness. Qatar, Oman, and Saudi Arabia's historical emergence in export-coreness is related to their growth as major global exporters of oil, especially Saudi Arabia.

And, of these nine countries, Singapore was the only historically semi-peripheral country whose change in rank score was associated with upward mobility into the top 30 of countries with the highest export-coreness. Therefore, the results show that significant upward mobility was limited and rare in both import- and export-coreness over the period of the crisis. Overall, these findings show that while greater upward mobility for periphery countries was expected in export-coreness and less so in import-coreness, the results suggest otherwise. Indeed, a small number of periphery countries were afforded more opportunities for upward mobility in import-coreness and much fewer opportunities in export-coreness. However, given the context of the global trade network and the impact of the 2008-09 global economic crisis, it is possible that the upward mobility of peripheral countries in import-coreness is more a sign of growing dependency rather than a growth in market power. Future research should explore whether there is a positive relationship between upward mobility in import-coreness and economic development to empirically validate this claim.

Nevertheless, the very small number of non-core countries that experienced any significant upward mobility over the period of the crisis further suggests that pathways are limited for these countries within the core-periphery structure. Therefore, optimistic claims that high levels of Global South-South trade during the period of the crisis along with the perceived decline of historically core countries would offer more pathways for a greater number of smaller developing countries to move up the hierarchy and diversify the very top of the hierarchy were discredited. The next section will examine the correlation of structural mobility between multiple

measures of coreness to assess whether one form of coreness is significantly associated with another form over the other.

2.5.4 Measuring Association of Structural Mobility Between Import- and Symmetrical Coreness

To examine whether upward mobility in import-coreness was strongly associated with symmetrical coreness over the period of the crisis, I followed a two-pronged approach. First, I computed a set of Pearson's r correlation coefficients on the rank order position of countries across all three types of coreness between 2007 and 2011. Whereas in the previous Pearson's r correlation coefficients examined inter-year correlation within each type of coreness (reported in tables 2.1, 2.2, and 2.3), these coefficients examine the correlation between these coreness measures 2007 to 2011. Second, I computed another set of Pearson's r correlation coefficients on the change scores of rank order position from 2007 and 2011 across all three coreness measures. This procedure was to determine if there is a strong and significant linear association between upward mobility in import- and symmetrical coreness over the period of the crisis. The aim of this two-pronged approach is to assess the level of overall change in structural position between 2007 and 2011 and examine the temporal association in structural mobility between all three types of coreness. These findings provide further evidence of a persistent and robust hierarchical, core-periphery structure that limit opportunities of many non-core countries to upwardly mobilize.

Table 2.5 *Top 30 Countries with Largest Change in Rank Order from 2007 to 2011 for Import Coreness (V) (Sorted by 'Rank Diff+' in Descending Order)*

	Country	Region	V-2007	V-2011	Rank 2007	Rank 2011	Rank Diff +
1	Mozambique	Sub-Saharan Africa	4.784	7.542*	40	117	77
2	Bahrain	Middle East & North Africa	6.834	8.282*	98	135	37
3	Mauritania	Sub-Saharan Africa	4.976	6.545	47	84	37
4	Burundi	Sub-Saharan Africa	2.332	4.929	12	46	34
5	Gambia	Sub-Saharan Africa	3.728	5.031	24	48	24
6	Singapore	Asia	9.024*	10.286*	153	175	22
7	Zambia	Sub-Saharan Africa	6.363	7.032	82	104	22
8	Mongolia	Asia	5.368	6.347	59	78	19
9	Lesotho	Sub-Saharan Africa	1.268	3.634	4	22	18
10	Nigeria	Sub-Saharan Africa	7.864*	8.574*	126	144	18
11	Sri Lanka	Asia	7.176*	7.801*	107	125	18
12	Benin	Sub-Saharan Africa	6.274	6.763	77	92	15
13	Malawi	Sub-Saharan Africa	5.459	6.291	62	75	13
14	Bahamas	Latin America & the Caribbean	3.487	4.642	23	35	12
15	Maldives	Asia	4.654	5.016	35	47	12
16	South Africa	Sub-Saharan Africa	9.083*	9.918*	157	169	12
17	Uruguay	Latin America & the Caribbean	6.764	7.318*	97	109	12
18	Azerbaijan	Middle East & North Africa	6.584	6.912	87	98	11
19	Cambodia	Asia	4.882	5.204	44	54	10
20	Madagascar	Sub-Saharan Africa	6.181	6.59	75	85	10
21	Panama	Oceania	5.152	5.588	52	62	10
22	Ecuador	Latin America & the Caribbean	7.153*	7.505*	106	115	9
23	Paraguay	Latin America & the Caribbean	5.957	6.373	70	79	9
24	Myanmar	Asia	5.005	5.367	48	56	8
25	Colombia	Latin America & the Caribbean	8.631*	8.757*	141	148	7
26	Argentina	Latin America & the Caribbean	8.179*	8.555*	137	143	6
27	Iraq	Middle East & North Africa	6.618	6.845	88	94	6
28	Jordan	Middle East & North Africa	7.708*	7.866*	121	127	6
29	Latvia	Europe	6.757	6.974	96	102	6
30	Vietnam	Asia	5.272	5.573	55	61	6

Note: * Significant at $p < 0.05$; one-tailed t-test of significance

Table 2.6: *Top 30 Countries with Largest Change in Rank Order from 2007 to 2011 in Export-Coreness (U)*
(Sorted by 'Rank Diff+' in Descending Order)

	Country	Region	U - 2007	U - 2011	Rank 2007	Rank 2011	Rank +
1	Sudan	Middle East & North Africa	3.656	5.969	34	85	51
2	Belize	Former Soviet States	4.432	5.183	50	65	15
3	Cambodia	Asia	6.679	7.476*	100	115	15
4	Qatar	Middle East & North Africa	7.54*	8.395*	120	134	14
5	Oman	Middle East & North Africa	7.452*	7.987*	116	129	13
6	Estonia	Europe	7.483*	7.99*	118	130	12
7	Belarus	Former Soviet States	7.062*	7.685*	109	120	11
8	Albania	Europe	5.318	5.846	71	81	10
9	Bosnia and Herzegovina	Europe	5.91	6.454	85	95	10
10	Mozambique	Sub-Saharan Africa	5.409	5.956	75	84	9
11	Lesotho	Sub-Saharan Africa	2.725	3.53	21	29	8
12	Nicaragua	Latin America & the Caribbean	5.375	5.95	74	82	8
13	Benin	Sub-Saharan Africa	3.915	4.384	38	45	7
14	Lithuania	Europe	8.122*	8.535*	131	138	7
15	Uganda	Sub-Saharan Africa	5.826	6.259	81	88	7
16	Zimbabwe	Sub-Saharan Africa	5.918	6.375	86	93	7
17	North Macedonia	Europe	5.374	5.811	73	79	6
18	Paraguay	Latin America & the Caribbean	6.085	6.621	93	99	6
19	Saudi Arabia	Middle East & North Africa	9.652*	9.876*	152	158	6
20	Serbia and Montenegro	Europe	6.092	6.704	94	100	6
21	Solomon Islands	Oceania	2.348	2.812	14	20	6
22	Angola	Sub-Saharan Africa	4.812	5.181	59	64	5
23	Antigua and Barbuda	Latin America & the Caribbean	3.614	3.987	33	38	5
24	Bhutan	Asia	1.917	2.377	7	12	5
25	Cabo Verde	Sub-Saharan Africa	2.631	3.079	18	23	5
26	Cameroon	Sub-Saharan Africa	6.588	6.904	99	104	5
27	Czech Republic	Former Soviet States	9.564*	9.693*	149	154	5
28	Iraq	Middle East & North Africa	5.001	5.324	63	68	5
29	Kyrgyzstan	Former Soviet States	4.014	4.478	41	46	5
30	Singapore	Asia	10.476*	10.545*	167	172	5

Note: * Significant at $p < 0.05$; one-tailed t-test of significance

The results also show that there is a strong and significant association in rank order change between import- and symmetrical coreness over the period of the crisis, which implies that, during the 2008-09 crisis, countries that experienced higher changes in rank order position in the former also experienced high rank order change in the latter. While this does not imply that high rank order change is associated with significant upward mobility over the period of the crisis, one can infer that there was nonetheless a significant association in upward mobility between two coreness measures from 2007 to 2011. Thus, upward mobility in import-coreness provided an avenue for countries to improve their position in the overall core-periphery structure over the period of the crisis.

Table 2.7 displays the inter-year correlation coefficients between rank order position from 2007 to 2011. All coefficients are strong and positive and are significant at the level of $p < 0.001$. These high correlation coefficients further indicate that the structural position of countries was highly stable throughout the period of the 2008-09 crisis. This is again consistent with Mahutga's (2006) research showing that strong and positive correlation coefficients detect significant structural stability in the top of the structure. The very strong correlation of $r = 0.98$ ($p > 0.001$) between symmetrical coreness and import-coreness of both 2007 and 2011 indicates a near 1.0 perfect correlation that is also stable. It should also be noted, however, that symmetrical coreness also has near 1.0 correlation with export-coreness with the difference in associations being very minimal. Nevertheless, the high levels of stability of structural positions suggest that the hierarchy of each type of coreness was robust to the 2008-09 crisis. Therefore, the high level of stability that is especially pronounced at the upper levels of the continuum implies further that the 2008-09 crisis did not have an equalizing effect on the core-periphery structure, nor did it result in profound changes within the very top of the hierarchy. These

findings do nonetheless validate the claims that large Global South countries such as China, India, and South Africa have converged with the core group of the global trade network and their high placement in the hierarchy is notable.

Table 2.7: *Intra- and Inter-Year Correlations of Export-, Import-, and Symmetrical Coreness from 2007 to 2011*

	W - 2007	V - 2007	U - 2007	W - 2011	V - 2011
W - 2007					
V - 2007	0.911****				
U - 2007	0.928****	0.867****			
W - 2011	0.992****	0.913****	0.934****		
V - 2011	0.896****	0.978****	0.863****	0.917****	
U - 2011	0.918****	0.868****	0.994****	0.931****	0.868****

Note: **** $p < 0.001$; two-tailed test

[a] W = Symmetrical, V = Import, U = Export

Within the high level of stability that characterizes the hierarchy of the global trade network, it was important to assess the covariance of structural mobility between all three coreness measures. As was discussed earlier, comparisons of change in rank order position in tables 2.5 and 2.6 (see far right column) display greater variation in change within import-coreness than in export-coreness. This further suggests greater structural stability within export-coreness than in import-coreness, and further implies that the 2008-09 crisis placed greater constraints on non-core countries to enhance their structural positions, especially within export-coreness. Yet, it is still important to assess whether variation in structural mobility within one form of coreness is strongly correlated with structural mobility in another form. In line with Boyd et al. (2010)'s expectations that high ranking in import-coreness is a better predictor of high ranking in symmetrical coreness, I expected that upward mobility in import-coreness would be strongly associated with upward mobility in symmetrical coreness.

Table 2.8 displays the correlation coefficients of structural mobility between all three measures of coreness and provides two important takeaways. First, the very strong and positive correlation of $r = 0.807$ ($p < 0.001$) indicates that upward mobility in import-coreness was significantly associated with upward mobility in symmetrical coreness over the period of the crisis. The second main takeaway from these findings is that upward mobility was more constrained in export-coreness than in import-coreness. As shown in table 2.8, the correlation coefficient of $r = 0.573$ ($p < 0.001$) between structural mobility in export- and symmetrical coreness is moderately strong and discernibly weaker than the $r = 0.807$ correlation coefficient between import- and symmetrical coreness. Furthermore, the correlation coefficient of $r = 0.177$ ($p < 0.01$) is weak and indicates that upward mobility in export-coreness had a weak relationship with upward mobility in import-coreness over the period of the crisis.

This is perhaps indicative of the severe drop in exports from the impact of the 2008-09 crisis which may have limited opportunities for upward mobility within export-coreness. Consequently, the only avenue available for countries to gain relative standing within the core-periphery structure was afforded through import-coreness. At the same time, however, the small number of upwardly mobile countries during the period of the crisis implies further that mobility overall was the exception and not the rule. The findings thus challenge expectations that growing Global South-South trade, especially throughout the period of the 2008-09 crisis, would generate significant mobility for many smaller developing countries through exports and that the emergence of China, India, and other large emerging countries was indicative of a waning hierarchical core-periphery structure. Rather, findings show that a core-periphery structure not only exists but persisted over the period of the crisis and the core-periphery structure provides limited avenues for non-core countries to mobilize up the hierarchy.

Table 2.8: *Within-Period Correlations of Rank Order Position Changes from 2007 to 2011*

	Import-Coreness Rank Diff	**Export-Coreness Rank Diff**
Import-Coreness Rank Diff		
Export-Coreness Rank Diff	0.177*	
Symm-Coreness Rank Diff	0.807****	0.573****

Note: * $p < 0.05$, **** $p < 0.001$; two-tailed test

2.6 Conclusion

In summary, this study explored whether the global trade network continually exhibited a hierarchical core-periphery structure in which countries occupy dominant positions and possess dominant roles vis-a-vis each other. Furthermore, the study explored whether patterns of structural mobility after the crisis suggested profound structural changes in the global trade network or has the relative position of countries remained stable after the crisis. In this context, the 2008-09 global economic crisis triggered a "global trade collapse" (Baldwin 2009) that led to synchronized and negative effects across the entire world economy. The crisis then raised debates about the hierarchy of the global trade network and economic globalization in general. I juxtaposed accounts that predicted the crisis would engender profound changes in the hierarchy of the global trade network with others that predicted persistent structural inequalities to exist long after the crisis. The goal of this study was to assess those predictions related to the impact of the 2008-09 global economic crisis on the hierarchy of the global trade network. To achieve this end, I set out to answer two main research questions related to the structure's hierarchical configuration and level of stability during the period of the crisis, on the one hand. And, on the other hand, I set out to answer a question related to the interplay between structural stability and

mobility within hierarchy over the period of a crisis. Findings from this study provide robust answers to the questions which have implications for future research on the global trade network.

This study produced several relevant findings about the impact of the crisis on the core-periphery structure of the international trade network. The first dimension of my SVD analysis provided a substantive structural measure of the global trade network. This measure captures the persistent and stable hierarchical nature of the global trade network that is notably correlated with the core-periphery concept from structural perspectives of economic globalization such as world-systems theory. The CUG tests empirically verified that the observed core-periphery structures across each time-period were far from what would be expected given the dyad census of the trade networks. The very strong and significant Pearson's r correlation coefficients of structural positions over the period of observation in tables 2.1, 2.2, and 2.3 provide strong evidence that the hierarchical structure of the global trade network has been stable over time. In addition, the correlation coefficients of structural mobility presented in tables 2.7 and 2.8 highlight the hierarchy's constraining nature on the upward mobility of non-core countries, especially the most periphery countries. Furthermore, these findings challenge claims that growing Global South-South trade in the wake of the 2008-09 crisis translated into greater convergence between smaller and larger developing economies. This is further supported by the results in tables 2.5 and 2.6 which show that despite large changes in rank order position amongst a large group of periphery countries, less than five countries experienced any significant upward mobility over the period of the crisis and three widely accepted semi-periphery narrowed their distance with the core group (Singapore, Indonesia, and South Africa).

Thus, rather than the "global rebalancing" that Pieterse (2011) claimed would occur after the crisis, the stability of the top tiers of the hierarchy with only minimal and predictable change

(i.e., China and India's extraordinary growth) suggest that core and core-like countries have benefitted from this growing globalization while countries at the lower tiers continue to compete to move up the hierarchy. Moreover, core and core-like countries exhibited greater structural stability throughout the period of the crisis. Whereas certain theoretical expectations portended a profound change in the structural configuration of the global trading system after the crisis, findings from this study suggest otherwise. The results suggest that the hierarchy remained robust to the crisis, despite it affecting the largest markets of the core. Therefore, the results are in line with Robinson (2015) who argues that the 2008-09 global economic crisis and the rise of China, India, and Brazil should not be viewed as dismantling old hierarchical systems of capitalist globalization, but rather that globalization continues to be characterized by related, contingent, and unequal transformations that maintain structural inequalities between countries. The events or changes that are observed should be understood because of globalized power relations and social structures that have formed over time. In sum, future macro-level research on the consequences of crises on globalization can benefit from attempts to generalize as to the impact of these large crises on the world economy. While this study was limited in focusing on aggregate trade and production, (not by specific sectors or industries), we can still learn from the use of aggregate trade data to gain a clearer understanding of the impact of a global economic crisis on the entire global trading system. Future study will explore whether mobility affects economic development at the micro-level of the world economy, as well as the standard of living beyond income (i.e., health outcomes). Exploring these kinds of questions will prepare us for understanding the impact of future economic crises, specifically the ongoing Covid-19 pandemic.

2.7 SUPPLEMENTAL TABLES: TOP 100 COUNTRIES IN EXPORT-, IMPORT- AND SYMMETRICAL CORENESS IN 2007 AND 2011 (SORTED BY RANK IN 2011 IN DESCENDING ORDER)

Table 2.9: *SVD Measures of Import-Coreness (V) and Rank Order Position from 2007 to 2011 (Sorted by 'Rank in 2011' in Descending Order)*

	Country	Region	V - 2007	V - 2011	Rank in 2007	Rank in 2011	Rank Diff +/-
1	United States	North America	12.128	11.806	191	191	0
2	China	Asia	11.711	11.783	189	190	1
3	Germany	Europe	11.851	11.455	190	189	-1
4	United Kingdom	Europe	11.597	11.261	187	188	1
5	France	Europe	11.6	11.233	188	187	-1
6	Netherlands	Europe	11.546	11.229	186	186	0
7	Italy	Europe	11.406	11.134	185	185	0
8	Japan	Asia	11.21	10.982	184	184	0
9	India	Asia	11.134	10.938	181	183	2
10	Spain	Europe	11.184	10.917	183	182	-1
11	Belgium	Europe	11.173	10.891	182	181	-1
12	Korea, South	Asia	10.726	10.806	179	180	1
13	Canada	North America	10.857	10.645	180	179	-1
14	Turkey	Middle East & North Africa	10.474	10.487	178	178	0
15	Switzerland	Europe	10.295	10.484	177	177	0
16	Russian Federation	Former Soviet States	10.218	10.328	175	176	1
17	Singapore	Asia	9.024	10.286	153	175	22
18	United Arab Emirates	Middle East & North Africa	10.071	10.277	172	174	2
19	Mexico	Latin America & the Caribbean	10.244	10.101	176	173	-3
20	Australia	Oceania	10.213	10.023	174	172	-2
21	Hong Kong	Asia	10.1	10.016	173	171	-2
22	Brazil	Latin America & the Caribbean	10.005	9.958	171	170	-1
23	South Africa	Sub-Saharan Africa	9.083	9.918	157	169	12
24	Indonesia	Asia	9.836	9.916	167	168	1
25	Malaysia	Asia	9.951	9.845	169	167	-2
26	Poland	Former Soviet States	9.835	9.809	166	166	0
27	Thailand	Asia	9.814	9.806	165	165	0
28	Sweden	Europe	10	9.733	170	164	-6
29	Saudi Arabia	Middle East & North Africa	9.481	9.698	160	163	3
30	Denmark	Europe	9.779	9.576	164	162	-2
31	Portugal	Europe	9.747	9.489	163	161	-2

32	Ukraine	Former Soviet States	9.196	9.413	158	160	2
33	Austria	Europe	9.718	9.26	162	159	-3
34	Greece	Europe	9.865	9.196	168	158	-10
35	Egypt	Middle East & North Africa	9.37	9.152	159	157	-2
36	Norway	Europe	9.512	9.136	161	156	-5
37	Pakistan	Asia	9.082	8.962	156	155	-1
38	Czech Republic	Former Soviet States	9.073	8.929	154	154	0
39	Ireland	Europe	8.992	8.844	152	153	1
40	New Zealand	Oceania	8.955	8.829	151	152	1
41	Morocco	Middle East & North Africa	8.815	8.774	147	151	4
42	Lebanon	Middle East & North Africa	8.857	8.767	149	150	1
43	Finland	Europe	9.076	8.766	155	149	-6
44	Colombia	Latin America & the Caribbean	8.631	8.757	141	148	7
45	Romania	Former Soviet States	8.845	8.742	148	147	-1
46	Algeria	Middle East & North Africa	8.773	8.73	145	146	1
47	Kuwait	Middle East & North Africa	8.65	8.671	142	145	3
48	Nigeria	Sub-Saharan Africa	7.864	8.574	126	144	18
49	Argentina	Latin America & the Caribbean	8.179	8.555	137	143	6
50	Serbia and Montenegro	Europe	8.684	8.513	144	142	-2
51	Kazakhstan	Former Soviet States	8.316	8.456	139	141	2
52	Chile	Latin America & the Caribbean	8.135	8.43	135	140	5
53	Angola	Sub-Saharan Africa	8.809	8.397	146	139	-7
54	Croatia	Europe	8.903	8.395	150	138	-12
55	Belarus	Former Soviet States	8.116	8.352	134	137	3
56	Hungary	Former Soviet States	8.684	8.337	144	136	-8
57	Bahrain	Middle East & North Africa	6.834	8.282	98	135	37
58	Philippines	Asia	8.006	8.234	130	134	4
59	Peru	Latin America & the Caribbean	8.104	8.227	133	133	0
60	Ghana	Sub-Saharan Africa	7.975	8.192	129	132	3
61	Bulgaria	Former Soviet States	8.38	8.18	140	131	-9
62	Tunisia	Middle East & North Africa	8.141	8.17	136	130	-6
63	Qatar	Middle East & North Africa	7.974	7.998	128	129	1
64	Slovenia	Europe	7.879	7.953	127	128	1
65	Jordan	Middle East & North Africa	7.708	7.866	121	127	6

66	Kenya	Sub-Saharan Africa	7.81	7.816	123	126	3
67	Sri Lanka	Asia	7.176	7.801	107	125	18
68	Slovak Republic	Former Soviet States	8.082	7.733	132	124	-8
69	Venezuela	Latin America & the Caribbean	8.286	7.733	138	124	-14
70	Tanzania	Sub-Saharan Africa	8.018	7.701	131	122	-9
71	Bosnia and Herzegovina	Europe	7.832	7.644	124	121	-3
72	Lithuania	Europe	7.531	7.626	116	120	4
73	Costa Rica	Latin America & the Caribbean	7.663	7.612	118	119	1
74	Mauritius	Sub-Saharan Africa	7.684	7.585	120	118	-2
75	Mozambique	Sub-Saharan Africa	4.784	7.542	40	117	77
76	Senegal	Sub-Saharan Africa	7.254	7.512	111	116	5
77	Ecuador	Latin America & the Caribbean	7.153	7.505	106	115	9
78	Trinidad and Tobago	Latin America & the Caribbean	7.361	7.408	114	114	0
79	Bangladesh	Asia	7.245	7.406	110	113	3
80	Ethiopia	Sub-Saharan Africa	7.682	7.403	119	112	-7
81	Dominican Republic	Latin America & the Caribbean	7.768	7.397	122	111	-11
82	Congo, DR	Sub-Saharan Africa	7.356	7.366	113	110	-3
83	Uruguay	Latin America & the Caribbean	6.764	7.318	97	109	12
84	North Macedonia	Europe	7.594	7.307	117	108	-9
85	Cameroon	Sub-Saharan Africa	7.474	7.157	115	107	-8
86	Oman	Middle East & North Africa	6.891	7.112	101	106	5
87	Israel	Middle East & North Africa	7.317	7.105	112	105	-7
88	Zambia	Sub-Saharan Africa	6.363	7.032	82	104	22
89	Cyprus	Middle East & North Africa	7.849	7.013	125	103	-22
90	Latvia	Europe	6.757	6.974	96	102	6
91	Albania	Europe	7.004	6.972	104	101	-3
92	Iran	Asia	7.201	6.949	109	100	-9
93	Libya	Middle East & North Africa	7.187	6.938	108	99	-9
94	Azerbaijan	Middle East & North Africa	6.584	6.912	87	98	11
95	Bolivia	Latin America & the Caribbean	6.837	6.901	99	97	-2
96	Iceland	Europe	6.866	6.891	100	96	-4
97	Malta	Europe	6.942	6.848	103	95	-8
98	Iraq	Middle East & North Africa	6.618	6.845	88	94	6
99	Moldova	Former Soviet States	6.741	6.804	95	93	-2

100	Benin	Sub-Saharan Africa	6.274	6.763	77	92	15

***Table 2.10**: SVD Measures of Export-Coreness (U) and Rank Order Position from 2007 to 2011 (Sorted by 'Rank in 2011' in Descending Order)*

	Country	Region	U - 2007	U - 2011	Rank in 2007	Rank in 2011	Rank Diff +/-
1	China	Asia	12.634	12.431	191	191	0
2	United States	North America	12.511	12.098	190	190	0
3	Germany	Europe	12.255	11.93	189	189	0
4	France	Europe	12.045	11.621	188	188	0
5	Italy	Europe	11.881	11.539	186	187	1
6	Japan	Asia	11.974	11.463	187	186	-1
7	India	Asia	11.561	11.41	183	185	2
8	United Kingdom	Europe	11.692	11.409	184	184	0
9	Netherlands	Europe	11.697	11.33	185	183	-2
10	Korea, South	Asia	11.394	11.075	182	182	0
11	Belgium	Europe	11.342	11.065	181	181	0
12	Spain	Europe	11.244	10.978	179	180	1
13	Brazil	Latin America & the Caribbean	11.303	10.968	180	179	-1
14	Switzerland	Europe	11.196	10.882	178	178	0
15	Thailand	Asia	11.184	10.881	177	177	0
16	Turkey	Middle East & North Africa	10.923	10.857	173	176	3
17	Malaysia	Asia	11.044	10.744	176	175	-1
18	Canada	North America	11.038	10.648	174	174	0
19	Sweden	Europe	11.04	10.625	175	173	-2
20	Singapore	Asia	10.476	10.545	167	172	5
21	Indonesia	Asia	10.655	10.53	170	171	1
22	Russian Federation	Former Soviet States	10.694	10.499	172	170	-2
23	Denmark	Europe	10.682	10.422	171	169	-2
24	South Africa	Sub-Saharan Africa	10.376	10.266	163	168	5
25	Austria	Europe	10.559	10.224	169	167	-2
26	Australia	Oceania	10.548	10.196	168	166	-2
27	Poland	Former Soviet States	10.198	10.165	162	165	3
28	United Arab Emirates	Middle East & North Africa	10.009	10.087	160	164	4
29	Ireland	Europe	10.407	10.074	165	163	-2
30	Hong Kong	Asia	10.411	10.023	166	162	-4
31	Vietnam	Asia	9.971	9.988	158	161	3

32	Finland	Europe	10.397	9.97	164	160	-4
33	Argentina	Latin America & the Caribbean	10.182	9.89	161	159	-2
34	Saudi Arabia	Middle East & North Africa	9.652	9.876	152	158	6
35	Mexico	Latin America & the Caribbean	9.871	9.866	157	157	0
36	Portugal	Europe	9.745	9.72	154	156	2
37	Norway	Europe	9.974	9.7	159	155	-4
38	Czech Republic	Former Soviet States	9.564	9.693	149	154	5
39	Ukraine	Former Soviet States	9.806	9.677	156	153	-3
40	Hungary	Former Soviet States	9.692	9.504	153	152	-1
41	Pakistan	Asia	9.786	9.499	155	151	-4
42	Egypt	Middle East & North Africa	9.567	9.453	150	150	0
43	New Zealand	Oceania	9.573	9.36	151	149	-2
44	Romania	Former Soviet States	9.176	9.352	146	148	2
45	Greece	Europe	9.274	9.273	148	147	-1
46	Chile	Latin America & the Caribbean	9.233	9.187	147	146	-1
47	Philippines	Asia	9.1	9.168	144	145	1
48	Bulgaria	Former Soviet States	9.131	9.12	145	144	-1
49	Morocco	Middle East & North Africa	8.627	8.883	139	143	4
50	Bangladesh	Asia	8.612	8.643	138	142	4
51	Sri Lanka	Asia	8.692	8.596	141	141	0
52	Israel	Middle East & North Africa	8.828	8.541	143	140	-3
53	Lithuania	Europe	8.122	8.535	131	138	7
54	Slovak Republic	Former Soviet States	8.698	8.535	142	138	-4
55	Colombia	Latin America & the Caribbean	8.682	8.474	140	137	-3
56	Slovenia	Europe	8.31	8.424	135	136	1
57	Peru	Latin America & the Caribbean	8.437	8.419	136	135	-1
58	Qatar	Middle East & North Africa	7.54	8.395	120	134	14
59	Tunisia	Middle East & North Africa	8.163	8.334	132	133	1
60	Luxembourg	Europe	8.242	8.227	134	132	-2
61	Uruguay	Latin America & the Caribbean	8.234	8.038	133	131	-2
62	Estonia	Europe	7.483	7.99	118	130	12

63	Oman	Middle East & North Africa	7.452	7.987	116	129	13
64	Ecuador	Latin America & the Caribbean	8.016	7.961	129	128	-1
65	Latvia	Europe	7.647	7.918	124	127	3
66	Cyprus	Middle East & North Africa	8.042	7.881	130	126	-4
67	Iran	Asia	8.583	7.871	137	125	-12
68	Costa Rica	Latin America & the Caribbean	7.716	7.853	126	124	-2
69	Kenya	Sub-Saharan Africa	7.75	7.753	127	123	-4
70	Nigeria	Sub-Saharan Africa	7.633	7.749	122	122	0
71	Lebanon	Middle East & North Africa	7.8	7.727	128	121	-7
72	Belarus	Former Soviet States	7.062	7.685	109	120	11
73	Croatia	Europe	7.644	7.667	123	119	-4
74	Jordan	Middle East & North Africa	7.578	7.642	121	118	-3
75	Malta	Europe	7.651	7.579	125	117	-8
76	Kuwait	Middle East & North Africa	7.395	7.569	114	116	2
77	Cambodia	Asia	6.679	7.476	100	115	15
78	Ghana	Sub-Saharan Africa	7.106	7.473	111	114	3
79	Ivory Coast	Sub-Saharan Africa	7.461	7.38	117	113	-4
80	Panama	Oceania	7.404	7.374	115	112	-3
81	Guatemala	Latin America & the Caribbean	7.105	7.332	110	111	1
82	Bahrain	Middle East & North Africa	7.004	7.116	107	110	3
83	Iceland	Europe	7.19	7.054	112	109	-3
84	Mauritius	Sub-Saharan Africa	6.824	7.045	106	108	2
85	Venezuela	Latin America & the Caribbean	7.485	6.992	119	107	-12
86	Tanzania	Sub-Saharan Africa	7.03	6.918	108	106	-2
87	Algeria	Middle East & North Africa	6.782	6.917	103	105	2
88	Cameroon	Sub-Saharan Africa	6.588	6.904	99	104	5
89	Honduras	Latin America & the Caribbean	6.743	6.872	101	103	2
90	Dominican Republic	Latin America & the Caribbean	6.807	6.832	104	102	-2
91	Kazakhstan	Former Soviet States	6.753	6.805	102	101	-1

92	Serbia and Montenegro	Europe	6.092	6.704	94	100	6
93	Paraguay	Latin America & the Caribbean	6.085	6.621	93	99	6
94	Cuba	Latin America & the Caribbean	6.809	6.606	105	98	-7
95	Ethiopia	Sub-Saharan Africa	6.202	6.508	96	97	1
96	Georgia	Middle East & North Africa	6.322	6.495	98	96	-2
97	Bosnia and Herzegovina	Europe	5.91	6.454	85	95	10
98	Senegal	Sub-Saharan Africa	6.145	6.418	95	94	-1
99	Zimbabwe	Sub-Saharan Africa	5.918	6.375	86	93	7
100	Trinidad and Tobago	Latin America & the Caribbean	6.241	6.322	97	92	-5

Table 2.11 *SVD Measures of Symmetrical Coreness and Rank Order Position from 2007 to 2011 (Sorted by 'Rank in 2011' in Descending Order)*

	Country	Region	W - 2007	W - 2011	Rank in 2007	Rank in 2011	Rank Diff +/-
1	China	Asia	37.536	38.629	190	191	1
2	United States	North America	38.89	37.568	191	190	-1
3	Germany	Europe	36.856	35.526	189	189	0
4	France	Europe	35.913	34.302	188	188	0
5	United Kingdom	Europe	34.668	33.667	187	187	0
6	Italy	Europe	33.754	33.256	184	186	2
7	Netherlands	Europe	34.178	33.219	185	185	0
8	Japan	Asia	34.467	32.989	186	184	-2
9	India	Asia	32.927	32.66	183	183	0
10	Korea, South	Asia	30.3	30.982	180	182	2
11	Belgium	Europe	31.371	30.882	182	181	-1
12	Spain	Europe	30.826	30.651	181	180	-1
13	Canada	North America	29.85	28.877	179	179	0
14	Switzerland	Europe	27.805	28.631	178	178	0
15	Turkey	Middle East & North Africa	27.225	28.589	176	177	1
16	Singapore	Asia	20.702	27.973	156	176	20
17	Thailand	Asia	27.074	27.475	175	175	0
18	Brazil	Latin America & the Caribbean	27.047	27.106	174	174	0
19	Malaysia	Asia	27.285	26.631	177	173	-4
20	Indonesia	Asia	25.538	26.623	170	172	2

21	Australia	Oceania	26.592	25.932	173	171	-2
22	South Africa	Sub-Saharan Africa	20.915	25.739	157	170	13
23	United Arab Emirates	Middle East & North Africa	23.554	25.629	165	169	4
24	Sweden	Europe	26.573	25.567	172	168	-4
25	Russian Federation	Former Soviet States	24.823	25.558	168	167	-1
26	Hong Kong	Asia	25.762	25.282	171	166	-5
27	Denmark	Europe	25.166	24.989	169	165	-4
28	Mexico	Latin America & the Caribbean	24.255	24.816	167	164	-3
29	Poland	Former Soviet States	22.981	23.996	164	163	-1
30	Saudi Arabia	Middle East & North Africa	20.486	22.83	154	162	8
31	Austria	Europe	23.925	22.433	166	161	-5
32	Portugal	Europe	22.222	22.279	163	160	-3
33	Ukraine	Former Soviet States	20.117	21.733	152	159	7
34	Pakistan	Asia	21.058	21.506	159	158	-1
35	Ireland	Europe	21.497	21.285	161	157	-4
36	Norway	Europe	21.133	20.504	160	156	-4
37	Finland	Europe	21.548	20.441	162	155	-7
38	New Zealand	Oceania	20.561	20.435	155	154	-1
39	Egypt	Middle East & North Africa	20.194	20.395	153	153	0
40	Greece	Europe	21.003	20.164	158	152	-6
41	Czech Republic	Former Soviet States	18.659	19.883	151	151	0
42	Argentina	Latin America & the Caribbean	17.839	19.235	149	150	1
43	Romania	Former Soviet States	17.254	18.487	148	149	1
44	Morocco	Middle East & North Africa	15.971	17.739	145	148	3
45	Hungary	Former Soviet States	18.034	17.455	150	147	-3
46	Chile	Latin America & the Caribbean	15.727	17.369	144	146	2
47	Philippines	Asia	15.447	17.265	142	145	3
48	Colombia	Latin America & the Caribbean	16.405	17.017	146	144	-2
49	Bulgaria	Former Soviet States	16.577	16.669	147	143	-4
50	Lebanon	Middle East & North Africa	15.593	15.892	143	142	-1
51	Peru	Latin America & the Caribbean	14.512	15.485	140	141	1
52	Tunisia	Middle East & North Africa	13.525	15.355	138	140	2

53	Sri Lanka	Asia	13.04	15.256	133	139	6
54	Nigeria	Sub-Saharan Africa	12.777	14.778	132	138	6
55	Croatia	Europe	14.789	14.677	141	137	-4
56	Kuwait	Middle East & North Africa	13.499	14.57	137	136	-1
57	Slovenia	Europe	13.156	14.401	135	135	0
58	Qatar	Middle East & North Africa	11.838	14.217	124	134	10
59	Lithuania	Europe	11.946	13.941	125	133	8
60	Slovak Republic	Former Soviet States	14.304	13.927	139	132	-7
61	Belarus	Former Soviet States	11.442	13.853	119	131	12
62	Ghana	Sub-Saharan Africa	11.79	13.661	123	130	7
63	Bangladesh	Asia	12.653	13.527	129	129	0
64	Kenya	Sub-Saharan Africa	12.759	13.389	131	128	-3
65	Bahrain	Middle East & North Africa	8.911	13.284	99	127	28
66	Costa Rica	Latin America & the Caribbean	12.45	13.253	128	126	-2
67	Israel	Middle East & North Africa	13.086	12.864	134	125	-9
68	Ecuador	Latin America & the Caribbean	11.257	12.74	118	124	6
69	Algeria	Middle East & North Africa	11.694	12.704	122	123	1
70	Serbia and Montenegro	Europe	11.203	12.614	117	122	5
71	Jordan	Middle East & North Africa	11.495	12.591	121	121	0
72	Uruguay	Latin America & the Caribbean	10.878	12.47	114	120	6
73	Kazakhstan	Former Soviet States	10.88	11.865	115	119	4
74	Mauritius	Sub-Saharan Africa	11.011	11.768	116	118	2
75	Tanzania	Sub-Saharan Africa	12.044	11.656	127	117	-10
76	Cyprus	Middle East & North Africa	13.203	11.649	136	116	-20
77	Oman	Middle East & North Africa	9.609	11.574	107	115	8
78	Latvia	Europe	9.906	11.479	110	114	4
79	Venezuela	Latin America & the Caribbean	12.755	11.375	130	113	-17
80	Dominican Republic	Latin America & the Caribbean	11.473	11.374	120	112	-8
81	Iran	Asia	12.007	11.163	126	111	-15
82	Luxembourg	Europe	10.526	11.147	113	110	-3

83	Senegal	Sub-Saharan Africa	9.481	10.831	103	109	6
84	Trinidad and Tobago	Latin America & the Caribbean	9.734	10.634	109	108	-1
85	Estonia	Europe	9.596	10.626	106	107	1
86	Malta	Europe	10.485	10.611	112	106	-6
87	Cameroon	Sub-Saharan Africa	10.092	10.593	111	105	-6
88	Vietnam	Asia	9.066	10.555	100	104	4
89	Bosnia and Herzegovina	Europe	9.198	10.524	102	103	1
90	Ethiopia	Sub-Saharan Africa	9.49	9.979	104	102	-2
91	Iceland	Europe	9.613	9.938	108	101	-7
92	Mozambique	Sub-Saharan Africa	4.375	9.801	57	100	43
93	Guatemala	Latin America & the Caribbean	9.194	9.652	101	99	-2
94	Cuba	Latin America & the Caribbean	9.514	9.345	105	98	-7
95	Angola	Sub-Saharan Africa	8.568	9.017	98	97	-1
96	North Macedonia	Europe	7.664	8.707	94	96	2
97	Madagascar	Sub-Saharan Africa	6.894	8.588	88	95	7
98	Georgia	Middle East & North Africa	7.666	8.441	95	94	-1
99	Albania	Europe	7.06	8.214	90	93	3
100	Honduras	Latin America & the Caribbean	8.372	8.141	97	92	-5

CHAPTER 3:
The Impact of the 2008-09 Global Economic Crisis on Economic Development: A Network Analysis of Global Trade Networks, 2001-2017

ABSTRACT

How did a country's structural position in the world-system impact their economic productivity before and after the 2008-2009 global economic crisis? Following the 2008-2009 crisis, debate emerged about global convergence and divergence between the poor and rich nation-states of the world economy. Specifically, whether the crisis led to an accelerated economic growth of peripheral and semi-peripheral economies that outpaced the growth of core nations. However, more than a decade later, debate remains about the crisis' impact in diminishing or reinforcing structural inequalities between the core and non-core economies. To answer this question, I conduct a social network analysis of the global trade network before and after the 2008-2009 crisis to map the hierarchical structure of the world economy. To test the association between position and development after a global economic crisis, I derive cross-nationally comparable measurements of world-system position of countries in the global trade network. I then regress cross-national variation in economic development on positional variation and mobility of countries along the structure of the world-system. Findings from this study show that economic development varies by structural position, especially in the post-2008-2009 crisis period. Second, I find that the highest rates of economic productivity occurred at the upper-middle tiers of the world-system. Third, countries in the lowest tiers of the world-system experienced greater negative productivity following the crisis. This suggests that the mechanism underlying persistent inequality following the 2008-2009 crisis was the absence of significant upward mobility for non-core countries. Taken together, these findings suggest that a country's economic

development following the 2008-2009 global economic crisis was conditioned by their position in the world-economic system.

3.1 Introduction

How did a country's structural position in the world economy impact their economy following the 2008-09 global economic crisis? Following the 2008-09 global economic crisis, debates emerged about the impact of the 2008-09 crisis on economic productivity and growth amongst the richest and poorest nations of the world economy. Pieterse (2011) claimed that the 2008-09 crisis was part of a global rebalancing process where "[e]merging societies are increasingly fulfilling core functions on the world-stage" and large regions of the Global South (Asia, Latin America, the Middle East, and Africa) are shaping a new geography of trade that will reconfigure the world economy. More critical perspectives claimed that the 2008-09 global crisis accelerated the predatory expansion of global capitalism and reinforced global class inequalities across the world economy (Robinson 2015, 2017; Sklair 2012). More than a decade later few studies have explored how the interrelationship between structural inequality and crisis significantly affected the national economies of countries.

This dissertation chapter enters the debate by providing an empirical study of the relationship between structural inequality in global trade networks and economic productivity of nation-states in the post-crisis era. To achieve this end, I turn to world-system theory and social network analysis to guide my analytical approach for this study. In this paper, I test the hypothesis that inequality between countries affected the economic productivity of nation-states following the crisis. For this study, I use data of international trade networks from the International Monetary Fund's *Direction-of-Trade Statistics* from 2001 to 2018 and national-level economic data from the World Bank's *World Development Indicators*.

3.2 Globalization, Cooperation, and Development in a Post-Crisis Era

An extremely optimistic and influential view of globalization argues that globalization "flattens out" the world and leads to economic dynamism everywhere, especially in the poorest areas of the world Wolf and Drezner (2005). Along this line of the thought, the surge in "Global South-South cooperation" (SCC)7 following the 2008-09 global economic crisis signaled a new era of globalization driven by the historically marginalized countries of the world. Through this prism, globalization over the course of the past 30 or so years proliferated strong economic and political relations between historically marginalized countries and clusters within the regions commonly associated with the Global South (Asia, Latin America, Africa, and the Middle East).

It is argued that these clusters are establishing a "counter-hegemonic movement" against the historically powerful 'core' countries and regions associated with the Global North (Altinbaş 2013; Gürcan 2019). Pieterse (2011) argues that the crisis resulted in two major developments: 1) creation of new development strategies that underscored global South-South relations as a new driver of economic development in the poorest regions of the world; and 2) divergence from old practices of neoliberalism[8] governed by historically dominant countries of the Global North, especially the US. Within these perspectives the surge in SSC after the 2008-09 crisis was viewed as a coherent response to the perceived recklessness of the US and Western European

[7] "Global South-South cooperation" (SSC) is a broad and popular term used by academics and policymakers to describe the substantial exchange of resources, technology, and knowledge between economically developing countries, also known as *Global South* countries. As larger developing countries (such as Brazil, China, South Africa, and India) emerge as dominant players in the world economy, they are increasingly making large contributions to global development and global governance. As a policy framework, Gray and Gills argue that SCC "conveys the hope that development may be achieved by the poor themselves through their mutual assistance to one another, and the whole world order [is] transformed to reflect their mutual interest's *vis-a-vis* the dominant global North" (2016: 557). For a more comprehensive account of SSC, see Modi (2011)'s edited volume, and for others see Altinbaş (2013); Garcia (2013); and Garcia (2016).

[8] Neoliberalism is conventionally used to refer to market-oriented policies such as deregulation of capital markets, lowering trade barriers, and diminishing the power of the welfare state and organized labor. These policies are commonly associated with the *Washington Consensus*, a set of economic policy prescriptions for crisis-ridden developing countries created by Washington DC based institutions such as the International Monetary Fund (IMF), World Bank, and the US Department of Treasury (Williamson 1993, 2004).

nations - the epicenters of the 2008-09 crises - and built upon a shared rejection of free-market capitalism and shared desire to chart their own economic development (Bremmer 2009; Nayyar 2011; Schmalz and Ebenau 2012).

However, diverging critiques exist about SSC's potential for promoting economic development in a post-crisis era. Several case studies, for instance, find that growing trade and cooperation between Global South countries, even in a post-crisis era, produced new forms of inequality in South-South relations while reinforcing historical imbalances in "North-South" economic relations (DeHart 2012; Gonzalez-Vicente 2017; Najam and Thrasher 2012). For example, Gonzalez-Vicente (2017) ethnographic study of Chinese mining investment in Ecuador finds that these relations reproduce power inequalities and processes of exclusion that are identical to the power imbalances within Global North-South relations. Consistent with this view, (Carmody 2017) argues that increasing economic commerce between the large emerging economies of the Global South with historically poor African countries remain largely hierarchical, and the poorest nations of Africa remain constrained to natural-resource intensive industries that are largely exported to the largest markets of the world. These case studies provide detailed accounts of the way in which economic and political inequalities are reinforced through so-called Global South-South relations. But, cases of exploitation can be read alongside cases of cooperation, and even cases of successful cooperation can have ambivalent implications for cooperation and development in other parts of the world. Thus, more than a decade later, debate about the impact of the 2008-09 crisis on the economic productivity of nation-states remains understudied and under-theorized. The contribution of this dissertation is to examine the impact of the 2008-09 crisis on the world economy through a structural-relational approach.

From these studies, I derive testable hypotheses that will guide this study. The first hypothesis emerges from the optimistic views of globalization in a post-crisis era. From this point of view, the crisis represented an opportunity for greater convergence between the poorest and richest nations in the world economy. In turn, we would expect the non-core areas of the world economy to outpace the economic productivity of core areas. An alternative hypothesis would be that the crisis represented an opportunity for only a select class of countries to benefit from the crisis. Studies that critiqued SSC and the "rise of the global south" thesis emphasize that the large emerging countries of the world economy (e.g., China, Brazil, India) shared some grounds for higher resilience and quick recovery from the crisis, including higher levels of financial regulation and relative importance of domestic markets (Schmalz and Ebenau 2012; also, Akyüz 2010; Garcia 2016; Ocampo 2009). But rather than a break from traditional relations that reinforced imbalances in Global North-South relations, according to Schmalz and Ebenau (2012), the crisis drove divergent practices within the three largest semi-peripheral countries of the world economy - China, India, and Brazil (BIC) - that do not reflect a radical break from neoliberalism, but rather continued implementing those practices.

Thus, from this perspective it can be hypothesized that the crisis represented an opportunity for only the large semi-peripheral countries such as Brazil, India, and China to gain from the crisis over the core and peripheral countries of the world economy. To test these hypotheses, I turn to a theoretical framework that will help to empirically test the impact of a country's structural position in the world economy after the 2008-09 crisis. To do so, I will use my structural analysis of the bilateral global trade network to see whether inequalities affect country-level economic productivity following the 2008-09 crisis. For this study, I implement an empirical approach that will allow me to control for period-specific effects that will test the

effect of structural position between a pre- and post-crisis period. In the following sections, I describe the theoretical framework that guides this study, world-system theory, and the analytical strategy of the empirical study. I then present results of the study and discuss their implications for a scholarly understanding of globalization and development following the 2008-09 global economic crisis.

3.3 Core-periphery structures in the world economy

3.3.1 Structural position

According to world-system theory, the world economy rests upon an international division of labor (IDL) that is hierarchically structured into three broad zones (core, periphery, and semi-periphery) with distinct types of trade specializations (Wallerstein 1974). "Core production is relatively capital intensive and employs skilled, high-wage labor; peripheral production is labor intensive and employs cheap, often politically coerced labor" (Chase-Dunn 1998: 77). The core-periphery distinction further differentiates between core countries that are much more integrated with the rest of the world economy and peripheral countries that are far less integrated (Mahutga and Smith 2011; Wallerstein 1976). Unlike optimistic accounts of globalization mentioned above, the core-periphery notion in world-system theory argues that globalization continues to compartmentalize countries into distinct positions within the core-periphery structure thereby reinforcing structural inequalities between core and peripheral countries.

Within the core-periphery structure exists a middle stratum known as the "semi-periphery" (Wallerstein 1976). Semi-peripheral countries raise the possibility of upward mobility in the world economy through "dependent development" where countries in the lower tiers of the IDL rely on importation of production from and exportation of manufactured goods to the core

(Evans 1979; Evans 2018). This then becomes the central mechanism in the growth of and the enhancement of domestic industries. In other words, semi-peripheral countries continue to depend "upon core powers to provide the capital, technology, and markets that make their development possible" (Nemeth and Smith 1985: 35). However, because of this dependent relation, significant upward mobility by developing states over the past several decades produced significant convergence in core/periphery trade relations with the growth of semi-peripheral countries outpacing that of their core and peripheral counterparts (Clark 2010; Kim and Shin 2002; Mahutga 2006).

It is this very dependence that affords semi-peripheral countries to move up the structure via the enhancement of their production capabilities. Unfortunately, access to these resources are not equally accessible across the lower tiers of the IDL with those in the lowest tiers (peripheral countries) with the least access. By the same token, peripheral states tend to experience slower economic productivity because of occupying a more exploited position, which intensifies their dependency on core nations. Scholars acknowledge that "growth miracles" of non-core countries such as Taiwan and South Korea stem from the internationalization of a growing share of manufacturing flowing out from core economies to non-core areas during downward economic phases (Chase-Dunn 1998; Mahutga and Smith 2011; Wallerstein 1972, 1976). Indeed, studies have found that semi-peripheral countries experienced positive upward mobility through industrial upgrading following downward phases of economic waves in the 1970s, which led to economic productivity that outpaced that of their core and peripheral counterparts (Mahutga and Smith 2011). Thus, a sharp economic downturn represents the greatest possibility for semi-peripheral countries to absorb the relocation of advanced industrial production from core areas

following a crisis. This fits in line with the hypothesis of the more critical perspectives mentioned above.

There are two hypotheses that correspond to different phases in the cycles of world-economic expansion and contraction. The first is a simple linear hypothesis: the core experiences more economic productivity during phases of economic upswings and downswings, and the semi-periphery are more economically productive than the periphery (Frank 1966; Santos 1970). An alternative hypothesis is consistent with a non-linear hypothesis: the semi-periphery grows faster than the core and the periphery during economic downswings (Wallerstein 1974). During world-economic upswings, core countries reap the benefits of an expansionary economy and the association between position in the world-system's hierarchy and economic productivity is linear. On the other hand, as Wallerstein (1974) suggests, when the world economy entered an economic downturn in the late 1960s, during which there was a relative profit advantage to the semi-peripheral nations" (464). Thus, select countries in the semi-periphery become the beneficiaries of the relocation of global industries to non-core countries. In other words, global economic downswings represent the greatest possibility for economic productivity owing to the greater openness of the system to the flow of industries from out of core areas. Mahutga and Smith (2011)'s network analysis of the international trade network from 1965 to 2000 finds that the highest rates of economic productivity occurred to countries in the middle tier of the core-periphery structure, especially during phases of economic downswings. Thus, a hypothesis that emerges from this perspective is the following:

> H_1: After the 2008-09 global economic crisis, countries that occupy middle positions in the core-periphery structure will generate greater economic activity than countries that do not occupy a middle position.

3.3.2 Structural mobility

While there are valid reasons to expect more economic productivity in the middle sections of the structural hierarchy, the mechanisms behind this dynamism remain under-studied and under-theorized. Structural mobility refers to a country's positive or negative change in the core-periphery structure from one period to another. The ability of countries to achieve upward mobility is constrained by their trade relations with the world economy and their geo-political role and power, which together condition a country's structural location within the core-periphery structure (Roberts, Grimes, and Manale 2003). Specifically, world-system theory asserts that the historical legacy of a country's incorporation into the world economy has a critical impact on a country's capacity to move up the hierarchy of the core-periphery structure (Chase-Dunn 1998; Wallerstein 1974).

A major issue within the literature is whether upward mobility generates positive development outcomes. Some acknowledge "growth miracles" in countries such as South Korea, Taiwan, and Hong Kong are a result of real upward mobility via the internationalization of a growing share of production activities that flow to and from core countries (Chase-Dunn 1998). Detractors from the upward mobility hypothesis suggest that upward mobility in the IDL is not a viable development strategy because it creates greater competition between formerly core activities. Moreover, globalization would likely "re-peripheralize" areas that are relatively less economically developed (Alderson and Beckfield 2004). Empirically, there are examples of upwardly mobile countries that experience substantive economic productivity (see Amsden 2001; Haggard 1990), countries that experience upward mobility but little to no substantive economic productivity (Schrank 2004), and countries that experienced neither upward mobility nor economic productivity (Frank 1970). In their attempt to resolve this issue, Mahutga and Smith's (2011) network analysis of global trade networks finds evidence that mobility is a viable

development pathway, but it is semi-peripheral countries that occupy structural positions that encourage upward mobility more than peripheral countries. In other words, the mechanism underlying rapid economic productivity in the semi-periphery was their uniquely high rates of upward mobility, which in turn is a function of their middle positions. Thus, in line with the previous hypothesis that predicts that mobility has a different effect on economic productivity after an economic downswing, a second hypothesis that is proposed is the following:

> H_2: Different rates of structural mobility will explain variation in economic productivity following the 2008-09 global economic crisis.

3.4 Data

The trade network data come from the International Monetary Fund's *Direction of Trade Statistics* (DOTS), which includes bilateral merchandise trade data for over 200 countries across a 1948-2018 period (International Monetary Fund 2014). The data are recorded in real US dollars and are adjusted for inflation. Using the DOTS, I created *N x N* trade matrices for odd years from 2001 to 2017 which yields 9 matrices and include a consistent sample of 191 countries. Given the skewed nature of trade flows, I use the base-10 logarithm of the raw data to measure ties. When constructing the trade network data, I relied on import data (trade flows reported *to* the reporting country from its partner) rather than export data (trade flows reported *from* the reporting country to its partner) as it is argued to be more accurate (Clark 2010; Kim and Shin 2002; Mahutga 2013). Thus, in the world trade network, ties are measured as the base-10 logarithm of the total value of all imports from country$_i$ to country$_j$.

The general statistical analysis incorporates both measures from trade networks and country-level measures. The country-level measures are obtained from the *World Development Indicators* (World Bank 2017) for the years of 2003 and 2017. In particular, the data through time (panel data) includes measures of structural position from network analysis of the

international trade network and national-level economic and demographic measures. Since I merge data and information from two different data sources, there were fewer than the 191 countries from the trade network data. As a result of excluding missing cases, the number of countries that are observed in the panel data drops from 191 to 164 countries and the years of observation ranges from 2003 to 2017. Therefore, the panel data are unbalanced (countries yield a different number of observations through time), containing a "large N, small T" sample (the number of countries greatly outnumbers the time-series observations), and time periods are unequally spaced (the gap during some years is greater than others). Nevertheless, the number of countries appearing in each year does not systematically vary with time and remains relatively constant, ranging from 159 to 164 countries in the data analysis.

Variables

Dependent Variable

Economic productivity is measured as the annual gross domestic product (at purchasing power parity) per capital for each country (logged). GDP PPP refers to the purchasing power parity (PPP) value of all final goods and services produced within a country each year, divided by the average population for the same year. Comparisons of national wealth are frequently made based on *nominal* GDP and savings (not just income); however, this measure does not reflect differences in the cost of living in different countries. Hence, using a PPP basis is arguably more useful when comparing generalized differences in living standards between nations because PPP considers the relative cost of living and the inflation rates of each country, rather than using only exchange rates, which may distort the real differences in income. Ultimately, this measure captures the economic output of a country per person in their population.

Independent Variables

Structural position is defined as a country's rank order position in the international trade network. Using singular value decomposition (SVD) of the nine trade matrices, I obtain coordinates of structural positions for all 191 countries. I used a country's level of coreness from the SVD analyses to determine a country's position on a continuous scale of 0 to 1 with non-negative numbers. I then sum these measures of in- and out-coreness measures to derive a single, aggregate measure of structural position. I use the aggregated measure of coreness to rank countries with higher ranked numbers indicating higher coreness status and smaller ranked numbers indicating lower core status. In other words, countries are *ranked* highest to lowest based on their SVD coordinates in each year, with rich countries like the US on the top and relatively poorer countries like Togo and Zimbabwe on the bottom.

Structural mobility is measured as the change in value of rank order position from time t to t_1, or $t_1 - t$, for each country.

Post-crisis effect is a dummy variable that accounts for the post-crisis period (2011 to 2017).

Control Variables

Life expectancy is defined as how long, on average a newborn can expect to live, if current death rates do not change. Life expectancy is a good measure of development as gains in life expectancy is attributed to several factors including rising living standards, improved lifestyle, and better education, as well as greater access to quality health services and improved infrastructure. Thus, it serves as a measure of human capital investment (Bank (2017)).

Trade openness Accounts for state policy as trade openness captures a state induced trade policy that stimulates economic productivity or raises trade barriers for protection against further external damage caused by the global crisis. For this measure, I rely on a country's trade as a

percent of gross domestic product. The higher a percentage, the more open and dependent the country is to international trade.

Population growth (annual percent change) annual population growth rate for year t is the exponential rate of growth of midyear population from year $t-1$ to t, expressed as a percentage. Population is based on the de facto definition of population, which counts all residents regardless of legal status or citizenship.

Labor force employed in industry (% of total employed) is defined as the percentage of persons of working age (15 - 64) who were engaged in any activity to produce goods or provide services for pay or profit, whether at work during the reference period or not at work due to temporary absence from a job, or to working-time arrangement, divided by the entire workforce population. The industry sector consists of mining and quarrying, manufacturing, construction, and public utilities (electricity, gas, and water). It is measured as a percentage of people employed in industry compared to the total labor force population. This measure controls for the level of industrialization that is present in the economy and accounts for domestic investment in industry (Bank 2017).

Initial Gross Domestic Product (GDP) (current $US) is measured as the annual sum monetary or market value of all finished goods and services generated by a national population, and it is measured in current $US dollars. To control for extreme asymmetries in values, I use the log base-10 logarithm.

3.5 Methods

3.5.1 Measuring Structural Position

To measure a country's structural position, I employ a singular value decomposition (SVD) analysis on the trade network at each period. Theoretically, networks that obey a core-

periphery structure feature a set of core actors who enjoy ties with all other actors, along with a set of peripheral actors who only share ties with the core and are isolated from one another. For this study, I employ a continuous coreness procedure using the statistical software, *R Studio*, and the *Tools for Social Network Analysis* (sna) package developed by Carter T. Butts (2008a) to compute network statistics and locate a country's location along the core-periphery structure in the global trade network. Continuous coreness scores range from 0 to 1, with larger values indicating greater coreness (or network integration), while smaller values indicate far less coreness (or network isolation). Another point of departure from previous studies is accounting for the asymmetry in international trade (i.e., the volume of trade from country$_i$ to country$_j$ may not equal the volume of trade from country$_j$ to country$_i$), and instead of a single label of "coreness" I use two types: out-coreness (based on extensive export relations) and in-coreness (based on extensive import relations). Computationally, the *singular value decomposition* of a real *m* by *n* matrix *X* of rank *r* is a triple of matrices (U, D, V) such that

$$X = UDV^t$$

where U and V are matrices that contain eigenvectors, and I used the first eigenvectors (those associated with the largest eigenvalue) as a measure of my measures of coreness. SVD decomposes the information contained in a data matrix into three matrices: a $U - 1$ dimensional U matrix summarizing the information in the rows, a $V - 1$ dimensional V matrix summarizing the information in the columns, and a $D - 1$ diagonal D matrix of singular values that summarizes the amount of variance explained by each dimension of U and V, where larger singular values correspond to higher explained variance. The SVD analysis assigns coordinates of in-coreness based on the results from the vector V and out-coreness from the results of the vector U.

Consequently, the in- and out-coreness scores are highly correlated with each other in each time. Thus, rather than relying on one type of coreness (either in- or out-coreness), I aggregate these coreness scores by summing in- and out-coreness coordinates for each country in each year. These coordinates are used to determine a country's rank position in the core-periphery structure. Higher rank order is associated with higher levels of coreness, for instance the US would rank 191 out of 191 countries whereas a small developing country such as Togo would rank closer to 1. Furthermore, I measure upward mobility as the change in rank-ordered position between each period for each country.

3.5.2 Panel Models

To test the hypotheses identified above, I estimate regression models where GDP per capita is regressed on indicators for structural position, mobility, and control variables. Also, to increase the statistical power of the models, I pool the observations across all time periods (from 2003 to 2017) because pooling these data allows me to account for omitted variables that vary across units but not over time (unit effects). A conventional approach to control for period-specific but country-invariant heterogeneity is Fixed Effects Modeling (FEM). An FEM approach is equivalent to Ordinary-Least Squares (OLS) that include a series of dummy variables for N-1 units. I include a period-specific dummy variable to control for pre- and post-period specific heterogeneity. This adds more strength to the analysis as it will test whether structural position and upward mobility has a different effect on economic productivity after the 2008-09 global economic crisis. To further test a post-crisis effect, I include an interaction term to test the hypothesis that a country's structural position and mobility has a different effect on economic productivity after the 2008-09 global economic crisis.

To further clarify the modeling approach, the entire regression analyses consist of eight main models that will contain the independent variables along with the control variables. The first model consists of a base model that estimates the effects of structural position on economic productivity. The second model introduced the period-specific dummy variable and an interaction term between the dummy variable and structural position. In other words, the second model will test for the effect of structural position on economic productivity after the crisis while controlling for period specific effects. To test whether countries occupying middle positions in the structural hierarchy will experience greater economic productivity in GDP per capita than countries in non-middle positions, I include a quadratic term for structural position in a third model. The quadratic term will test whether the effect of structural position is curvilinear. If significant and negative, the quadratic term will provide strong evidence that countries occupying middle positions in the structural hierarchy will experience greater economic productivity than countries in non-middle positions. The fourth model interacts the quadratic term with the post-crisis dummy variable to test the second main hypothesis that countries occupying middle positions will experience greater economic productivity after the 2008-09 crisis than countries that are not in middle positions. Thus, the first four models test the effect of position and whether middle positions are structurally positioned to experience greater economic productivity in the post-crisis period.

A fifth model will test the effect of structural mobility on economic productivity throughout the period of observation. A sixth model will include the post-crisis period effect and will test the hypothesis that different rates of structural mobility will explain variation in GDP per capita productivity following the 2008-09 global economic crisis. A seventh model integrates structural position to test the effect of mobility while controlling for their position in each year.

An eighth and full model includes all the main independent variables, the interaction and quadratic terms, and all control variables. This full model is included to assess the extent to which the main independent variables are robust to alternative estimators and period-specific effects.

These equations can be written formally as:

$$\begin{aligned}\text{GDP per capita (PPP) annual productivity} = {} & \beta_0 + \beta_1 \text{Structural position} + \\ & \beta_2 \text{Position}^2 + \beta_3 \text{Post-crisis} + \\ & \beta_4 \text{Position} * \text{Post-crisis} + \beta_5 \text{Position}^2 * \text{Post-crisis} + \\ & \beta_6 \text{Mobility} + \beta_7 \text{Mobility} * \text{Post-crisis} + \\ & \beta_8 \text{Initial GDP PC (PPP)} + \beta_9 \text{Life expectancy} + \beta_{10} \text{Trade openness} + \beta_{11} \text{Pop growth} + \\ & \beta_{12} \text{Pct Employed in Industry} + \alpha_i + u_{it}\end{aligned}$$

With $i = 1, \ldots, n$ and $t = 1, \ldots, T$. The α_i are the entity-specific intercepts that capture heterogeneity across countries. Having individual specific intercepts $\alpha_i, i = 1, \ldots, n$ where each of these can be understood as the fixed effect of country i. The variation in $\alpha_i, i = 1, \ldots, n$ comes from unobserved time-invariant heterogeneities across countries and can be rewritten as a regression model containing $n - 1$ dummy variables and a constant.

3.6 Results

3.6.1 Examining the association between structural position and economic productivity

Table 3.1 reports descriptive statistics (count, mean, standard deviation, variance, standard error, and range (minimum and maximum) for the percent change in GDP per capita (PPP) across each year of observation.[9] As is shown, percent change in GDP per capita from 2001 to 2017 increased to above one percent in 2005 with a mean of 1.493 ($sd = 0.941$) and

[9] Average annual percent change in GDP per capita was measured as a percent change: log(GDP PC_{t1}) – log(GDP PC_{t0}) / log(GDP PC_{t0}).

peaked in 2007 with a mean of 1.650 ($sd = 0.916$). No other period in the data had an annual percent increase that was greater than one percent. Figure 3.1a-3.1d display the univariate distribution of GDP per capita (PPP) change across all periods and then two distinct periods: pre-crisis (2003-2007) and post-crisis (2011-2017). The patterns in figure 3.1a show that the percent change in GDP per capita (PPP) ranged from -5% to +5% percent from 2001 to 2017. Figures 3.1b and 3.1c further illustrate the range of percent change ranged from -5% to +5% in pre- and post-crisis periods, respectively. This is further illustrated in table 3.1 which reports the descriptive statistics for GDP per capita while tables 3.2 compares GDP per capita (PPP) growth across the pre- and post-crisis periods, respectively. The average annual percent change in GDP per capita was 1.352 in the pre-crisis period ($n = 481; sd = 1.024$) and 0.769 in the post-crisis period ($n = 645; sd = 1.162$), with slightly less variation in the pre-crisis period. The 95% confidence intervals for the pre-crisis period $(1.26, 1.444)$ and the post-crisis period $(0.665, 0.873)$ do not overlap which provides evidence that the differences in average annual economic change are not statistically significant. In other words, the evidence suggests that the percent change in GDP per capita was larger on average in the pre-crisis period (2003-2007) than in the pre-crisis period (2011-2017) and points to the lasting impact of the 2008-09 global economic crisis.

Table 3.1 *Descriptive statistics of GDP per capita (PPP) percent change by year, 2003 - 2017*

Year	*N*	*Mean*	*SD*	*Var*	*SE*	*Min*	*Max*
2003	159	0.907	1.063	1.129	0.084	-4.751	4.143
2005	159	1.493	0.941	0.885	0.075	-0.922	6.262
2007	163	1.650	0.916	0.840	0.072	-0.997	6.306
2009	164	0.563	0.816	0.666	0.064	-2.155	2.988
2011	164	0.990	1.088	1.183	0.085	-8.841	4.304
2013	161	0.850	1.148	1.319	0.091	-4.563	5.866
2015	161	0.434	1.367	1.869	0.108	-4.912	6.263
2017	159	0.800	0.940	0.883	0.075	-4.614	3.804

Table 3.2 *Descriptive statistics of percent change in GDP per capita compared across pre- and post-crisis periods*

Pre-Crisis Period (2001 - 2007)						
Count	Mean	Std. Dev	Var	Std Error	95% CI Lower	95% CI Upper
481	1.352	1.024	1.049	0.047	1.26	1.44
Post-Crisis Period (2011 - 2017)						
Count	Mean	Std. Dev	Var	Std. Error	95% CI Lower	95% CI Upper
645	0.769	1.162	1.351	0.053	0.665	0.873

Figure 3.1*: Histograms of GDP Per Capita (PPP) Percent Change*

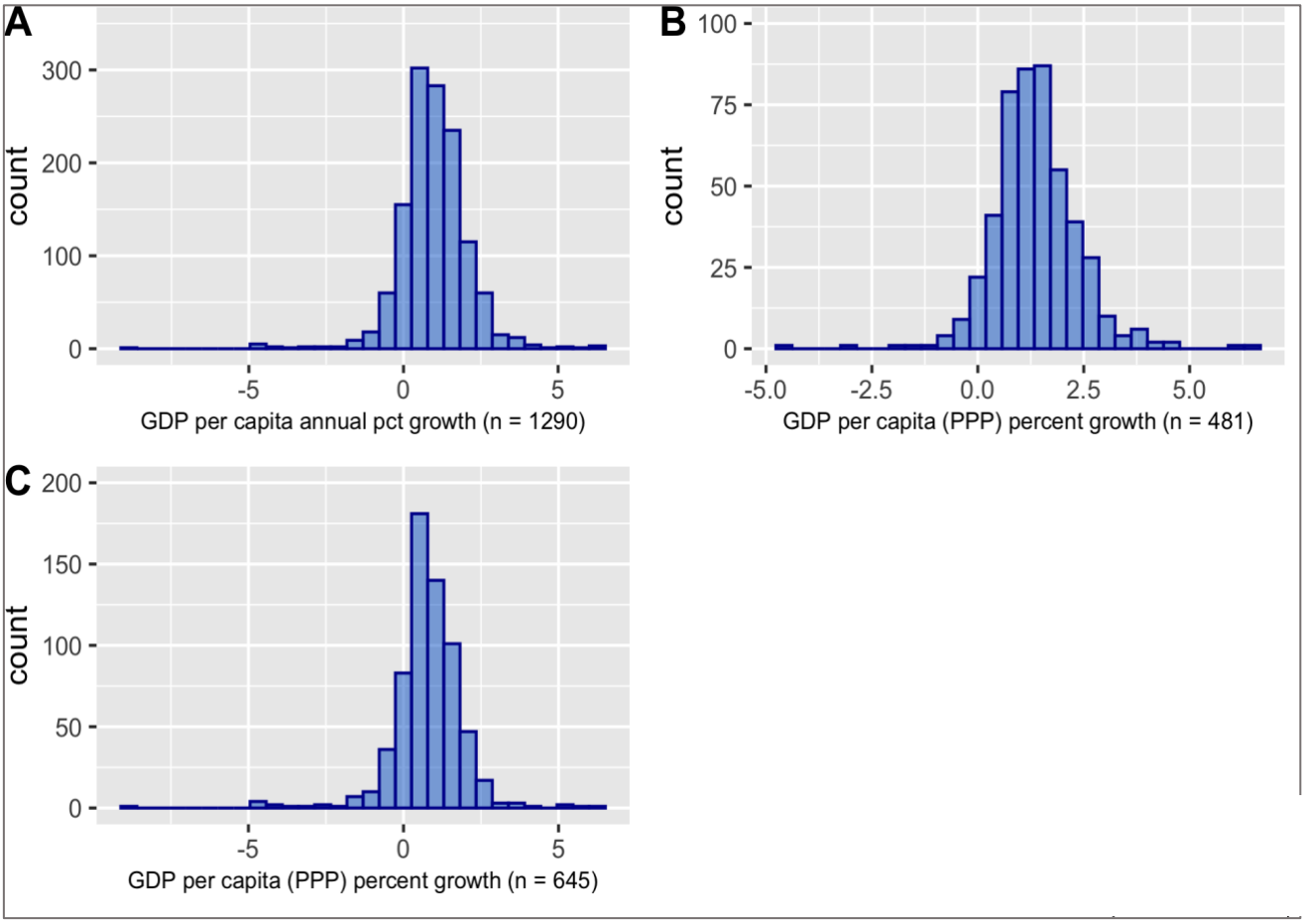


Figure 3.2 displays a scatterplot that examines the bivariate relationship between GDPs per capita (PPP) and structural position. The scatterplot illustrates a positive and linear relationship between a country's structural position and their aggregate GDP per capita (PPP) each year. This pattern confirms to a core-periphery structure where core countries generated

greater economic productivity than non-core countries. To further confirm this expectation, I computed Pearson's *r* correlation coefficients to test the within-year association between structural position and GDP per capita across each year of observation. Table 3.4 displays positive and significant associations that appear strong and stable across time. Figure 3.3 compares the association between structural position and GDP per capita across the pre- and post-crisis periods. As is expected, the association between structural position in the global trade network and economic productivity remains strong despite the impact of the crisis on international trade. Therefore, it is reasonable to infer that structural position and economic productivity are strongly correlated with each other, both before and after the 2008-09 global economic crisis.

Table 3.3: *Descriptive statistics of international trade network, 2001 - 2017*

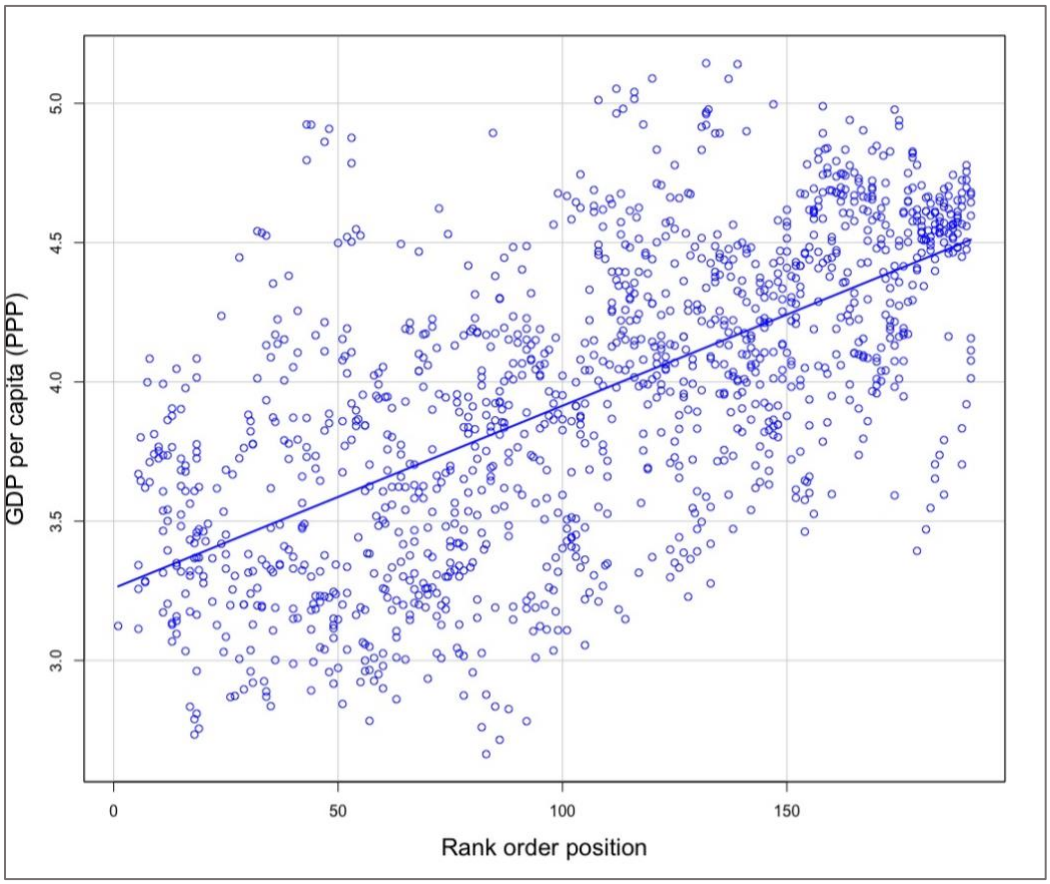
Years	Total Edges	Mean Degree	Density	Reciprocity	Transitivity
2001	20,793	108.73	0.573	0.763	0.74
2003	21,684	113.06	0.598	0.759	0.753
2005	22,017	115.54	0.607	0.764	0.759
2007	22,761	119.34	0.627	0.757	0.771
2009	23,492	122.99	0.647	0.754	0.785
2011	24,333	127.40	0.671	0.768	0.797
2013	24,672	129.17	0.68	0.769	0.803
2015	25,197	131.92	0.694	0.771	0.809
2017	25,447	133.23	0.701	0.769	0.815

Table 3.4 *Within-Year Correlations of GDP per capita (PPP) and Structural Position from 2003 to 2017*

Years	**2003**	**2005**	**2007**	**2009**	**2011**	**2013**	**2015**	**2017**
r	0.65****	0.64****	0.64****	0.67****	0.64****	0.64****	0.65****	0.63****

Note: **** $p < 0.0001$

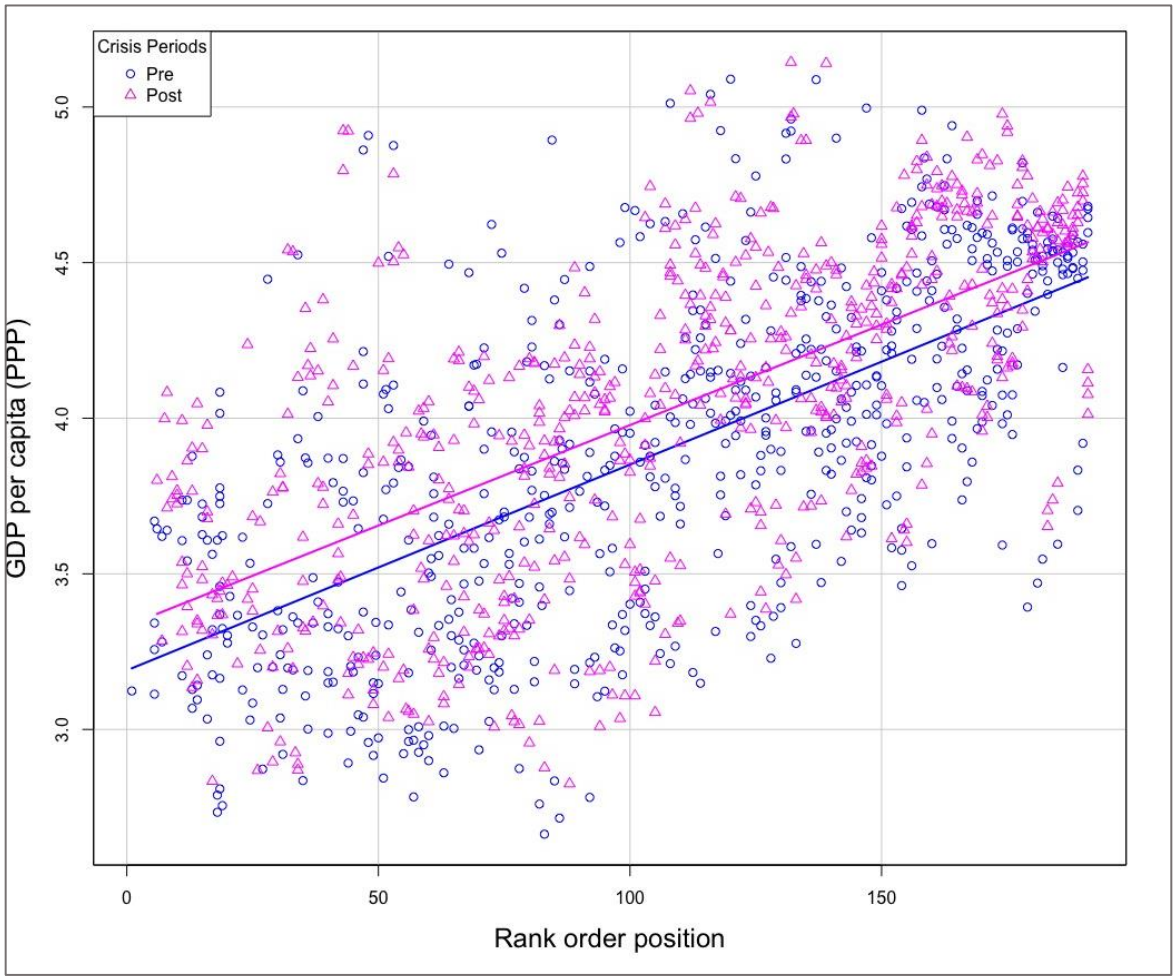
Figure 3.2 *Measurement of Association Between GDP per capita (PPP) and structural position*



Based on these descriptive statistics, I infer three relevant conjectures. First, both figures 3.2 and 3.3 display positive and significant association between structural position and annual economic output. To assess whether this association is consistent within each year, I computed Pearson r correlation coefficients between rank order position and GDP per capita across each year. As mentioned earlier, table 3.4 displays the coefficients that show a stable and strong association between the two variables. All the correlation coefficients are above 0.6, which indicate a strong association, and are significant at $p < 0.001$. Second, figure 3.3 illustrates the durability of this association after the 2008-09 crisis and further illustrates the relevance of higher status in the core-periphery for economic productivity after the crisis. This relates to the third conjecture, which relates to the network statistics. Results from table 3.3. show that

network connectivity has been increasing monotonically over the 17-year period of observation, but this trend slowed down after the 2008-09 crisis. Therefore, despite the monotonic increases in network connectivity over time, the association between structural position in the global trade network and economic productivity did not change. In other words, the increase in network connectivity could be a mechanism for stabilizing the positive and significant association between position and economic productivity and possibly vice-versa as well. Future research should consider examining this association. The next section discusses the regression models that were conducted to test the hypotheses that motivated this analysis.

Figure 3.3 *Comparing association between structural position and GDP per capita across pre- and post-crisis periods*



3.6.2 Panel Regression Models

Table 3.5 reports the unstandardized coefficients from the fixed-effects regressions of economic productivity. Model 1 regressed structural position and the fixed unit and period specific effects on the dependent variable. As expected, given the bivariate relationship displayed in figures 3.2 and 3.3, there is a statistically significant relationship between structural position and economic productivity ($\beta_{pos} = 0.001; p < 0.001$). Model 1 also displays significant associations between the control variables and the dependent variable. Two demographic measures - higher life expectancy and population growth – were positively associated with economic prosperity. Model 2 includes the post-crisis period effect into the model and its interaction with structural position. The coefficient for the interaction term is positive and significant ($\beta_{pos*pcp} = 0.0003; p < 0.01$) while the post-crisis effect was also significant, but negative ($\beta_{pcp} = -0.02; p < 0.1$). These coefficients indicate that structural position was significant throughout the period of observation, and more importantly, that higher coreness status was associated with greater economic productivity after the crisis. More specifically, the positive interaction term ($\beta_{pos*pcp}$) for position and the post-crisis effect indicates that there is an expected increase in economic productivity after the crisis for countries that occupy higher positions. Therefore, structural position was a significant factor in economic productivity after the 2008-09 crisis, which shows that the effect of structural position was significant for countries to recover after the crisis.

The third model contains structural position, the post-crisis period effect, and the quadratic term for position. As mentioned earlier, the quadratic term is included to test the hypothesis that greater economic productivity will be observed in the middle-tier positions of the core-periphery structure. If the quadratic term is negative and significant, it provides evidence of

an expected curvilinear relationship between economic productivity and middle-tier structural positions. As is shown in table 3.5, the coefficient for the quadratic term is negative and significant ($\beta_{pos^2} = -0.00004; p < 0.1$). In addition, model 4 introduced two interaction terms: 1) between structure and post-crisis period effect ($\beta_{pos*pcp}$) and 2) between the quadratic term for structural position and post-crisis period effect (β_{pos^2*pcp}). The coefficient for the first interaction term was not significant ($\beta_{pos*pcp} = -0.0004; p = 0.136$); however, the second interaction term was significant and slightly positive ($\beta_{pos^2*pcp} = 0.000003$; $p < 0.01$). In addition, the coefficients for position ($\beta_{pos} = 0.001; p < 0.01$) and the quadratic term were both also significant ($\beta_{pos^2} =$ -0.00001; $p < 0.1$) in model 4. In observing, the coefficients for position, the quadratic term, and the significant interaction term between the quadratic term and post-crisis period effect indicate patterns of a curvilinear relationship that trends slightly upward after the 2008-09 crisis. In other words, the curvilinear relationship trends downward up until the 2008-2009 crisis when it appears to increase slightly upwards.

Two relevant conjectures can be derived from the results of models 1 through 4. First, the findings support the theoretical expectation that higher placement in the core-periphery structure is positively associated with economic productivity. Second, models 3 and 4 confirm the expectation that countries in the middle-tiers of the core-periphery structure display greater economic productivity, and this relationship persisted after the 2008-09 crisis. Therefore, the first series of regression models support the claims of hypothesis 1 that greater economic productivity will be observed in the middle-tiers of the core-periphery structure. The next section describes the next four models that account for structural mobility before and after the 2008-09 crisis.

Table 3.5 *Unstandardized coefficients from regression of economic productivity and structural position*

	Model 1	**Model 2**	**Model 3**	**Model 4**
Independent variables				
Structural position	0.001***	0.004***	0.001***	0.001***
	(0.0002)	(0.0002)	(0.0004)	(0.0004)
Position * Post-crisis period		0.0003***		-0.0004
		(0.0001)		(0.0002)
Position^2			-0.000004*	-0.00001*
			(0.000002)	(0.000002)
Position^2 * post-crisis period				0.000003***
				(0.000001)
Post-crisis period		-0.02*	0.017***	0.004
		(0.005)	(0.005)	(0.011)
Control variables				
Life Expectancy	0.005***	0.004***	0.004***	0.005***
	(0.001)	(0.001)	(0.001)	(0.001)
Trade openness	0.0004***	0.0003***	0.0003***	0.0003***
	(0.0001)	(0.0001)	(0.0001)	(0.0001)
Population growth (Pct)	0.01***	0.01***	0.01***	0.01***
	(0.002)	(0.002)	(0.002)	(0.002)
Pct employed in Industry	-0.006***	-0.005***	-0.005***	-0.004***
	(0.001)	(0.001)	(0.001)	(0.001)
GDP (Logged)	0.195***	0.184***	0.185***	0.185***
	(0.005)	(0.006)	(0.006)	(0.006)
Obs.	1,290	1,290	1,290	1,290
Adjusted R-squared	0.73	0.74	0.733	0.743
F-statistic	609.908***	530.276***	465.207***	389.637***

Note: * p < 0.1; ** p < 0.05; *** p < 0.01

To test hypothesis two that varying levels of structural mobility will explain different levels of economic productivity, especially after the 2008-09 global economic crisis, I conducted four regression models and the results are shown in table 3.6. Model 5 tests the relationship between structural mobility and economic productivity. The coefficient and p-value for structural

mobility ($\beta_{mobility} = 0.002; p =< 0.1$) show a positive and significant relationship between upward mobility and economic productivity. Model 6 introduced the period-specific dummy variable along with an interaction with the upward mobility to test the claims of hypothesis 2. However, the coefficient and the p-value of the interaction term ($\beta_{mobility*pcp} = 0.003; p = 0.444$) indicate a non-significant interactive relationship between mobility and post-crisis economic productivity. Nevertheless, the coefficients for the individual effects of mobility ($\beta_{mobility} = 0.0003; p < 0.1$) and the post-crisis period specific dummy variable ($\beta_{pcp} = 0.017; p < 0.01$) were statistically significant. These results may reflect the influence of structural mobility on economic productivity throughout the period of observation. In addition, the post-crisis coefficient, which was positive and significant, points to a significant rebound in economic productivity after the crisis.

Model 7 tests the effect of structural mobility while controlling for structural position. The effect of structural mobility becomes non-significant when controlling for structural position. The final model is a full model that includes both the main independent variables, the quadratic term for structural position, and the interaction terms of the independent variables with the post-crisis period-specific dummy variable. The model shows that when controlling for both position and mobility in the model, the coefficient for structural position is statistically significant ($\beta_{pos} = 0.002; p < 0.1$). The coefficients for mobility in both models 7 and 8 show that variation in upward mobility does not explain economic productivity when controlling for structural position. Therefore, the results of models 5 through 8 provide evidence against hypothesis 2 and show the effect of mobility does differ between the pre- and post-crisis periods. Nevertheless, these results show the persistent effect of higher placement in the core-periphery structure on economic prosperity, even more so after the 2008-09 crisis.

Table 3.6 *Unstandardized coefficients from regression of economic productivity on structural mobility*

	Model 5	**Model 6**	**Model 7**	**Model 8**
Main variables				
Mobility	0.0002*	0.0003*	-0.0002	0.0004
	(0.0001)	(0.0001)	(0.0001)	(0.0003)
Position			0.001***	0.002***
			(0.0002)	(0.0005)
Position * Post-crisis period				-0.0004
				(0.0002)
$Position^2$				-0.00001
				(0.000002)
$Position^2$ * post-crisis period				0.000003***
				(0.000001)
Mobility * Post-crisis period		0.0003		0.0003
		(0.0002)		(0.00003)
Post-crisis period		0.017***	0.017***	0.004
		(0.005)	(0.005)	(0.012)
Control variables				
Life Expectancy	0.005***	0.004***	0.005***	0.005***
	(0.001)	(0.001)	(0.001)	(0.001)
Trade openness	0.0004***	0.0004***	0.0003***	0.0003***
	(0.0001)	(0.0001)	(0.0001)	(0.0001)
Population growth (Pct)	0.01***	0.01***	0.011***	0.011***
	(0.002)	(0.002)	(0.002)	(0.002)
Pct employed in Industry	-0.005***	-0.004***	-0.004***	-0.004***
	(0.001)	(0.001)	(0.001)	(0.001)
GDP (Logged)	0.195***	0.184***	0.184***	0.184***
	(0.005)	(0.006)	(0.006)	(0.006)
Obs	1,290	1,290	1,290	1,290
R squared	0.764	0.767	0.769	0.778
F statistic	602.076***	523.351***	464.249***	324.999***

Note: * p < 0.1; ** p < 0.05; *** p < 0.01

3.7 Discussion and Conclusion

This study produced several important findings. The first dimension of my analysis finds that rates of annual growth in GDP per capita tapered after the 2008-09 crisis. This measure illustrates the potential lasting impact of the crisis on national economic productivity. The second dimension of my analysis was a series of fixed effects regression models that tested both a) the effect of structural mobility on economic productivity and b) the hypothesis that countries in the middle-tier of the core-periphery structure experience greater economic productivity after a crisis. The results of these models provide evidence in support of hypothesis 1 that predicted that placement in the middle-tier structural positions experience a boost in economic productivity, especially after the 2008-09 crisis. The third dimension was another series of fixed effects regression models that tested the effect of structural mobility on economic productivity while controlling for structural position. These findings did not offer support for hypothesis 2, which predicted that various levels of upward mobility would be positively associated with greater economic productivity after the crisis. Instead, the models offered further evidence that higher structural placement was an important factor in generating economic productivity after the 2008-09 crisis. However, mobility in the structure was not enough for countries to experience greater economic productivity than would otherwise be expected.

While this study was limited to assessing whether economic productivity after a global economic crisis was contingent upon structural placement in the global trade network's hierarchy, it would be interesting to explore the impact of the 2008-09 on economic productivity across multiple networks of industries such as footwear, textiles, and automobile production. Asking these kinds of questions would further clarify the impact of 2008-09 crisis on the individual global value chains which are a part of the larger global trade network. As the world

currently experiences another global economic crisis due to the Covid-19 pandemic, future studies should explore how globalization, especially through growing embeddedness in the global trade network, plays a role in offsetting the adverse effects of a crisis. This study provides a launching pad for triangulating a connection between crisis, globalization, and economic development to comprehend how structural inequalities underline a country's economic recovery following a widespread economic crisis.

CHAPTER 4:
Conclusions And Future Research Directions

The main goal of this study was to answer three main questions: 1) *how did the global trade network adapt and respond to the 2008-09 global economic crisis?* 2) *In what ways did the 2008-09 crisis affect economic inequalities between nation-states?* And 3) *how did the 2008-09 crisis affect the dynamic interplay between the macro-level structure of the global trade network and economic productivity of nation-states?* To answer these questions, I situated my study within social network analysis and economic sociology to develop an analytical framework in which to triangulate a link between the impact of the 2008-09 crisis on trade globalization, the structural composition of the global trade network, and economic productivity to provide a sociological understanding on the impact of a global economic crisis on globalization and national economic productivity. This dissertation demonstrates the applicability of social network analysis to model the global trade network and to evaluate its structure and dynamics during and after a global economic crisis. Below, I highlight main contributions and some suggestions regarding future directions of research related to this work.

4.1 Summary of Findings and Implications

This study produced several important findings. The first dimension of my analysis applied network measures of density, reciprocity, transitivity, degree centrality, and degree centralization, which was done in chapter 1. Measures of density captured the continued expansion of the global trade network from 2001 to 2017, and the temporal CUG tests provided evidence that density in each period was substantially greater than in the previous period. Furthermore, the proportion of transitive ties and mean degree centrality in the global trade network increased monotonically from 2001 to 2017. These trends along with a linear decrease in in- and out-degree centralization reflects rising connectivity and multilateralism within the

global trade network. The inverse linear relationship between increasing connectivity and decreasing centralization reflects a greater distribution of trade flows across the entire global trade network. More importantly, the results show that these trends were not noticeably affected by the crisis. While connectivity and the mean $US dollar volume of trade appeared slower in the post-crisis period, future research will have to directly test a null hypothesis that the changes from the pre- to post-crisis periods were not significantly different. The results, nevertheless, show that density has substantially increased in each subsequent year and two other network measures of connectivity - transitivity and reciprocity - are not entirely a result of internal network properties such as dyad census and network size and number of edges, respectively. Thus, I argue that economic globalization through international trade remained steadfast and persistent despite the severe impact of the 2008-09 crisis on international trade, and the trends of connectivity and multilateralism were far from what would be expected given certain network characteristics.

The second dimension of this dissertation examined the impact of the 2008-09 crisis on structural inequalities between nation-states. I point to two relevant trends from this study. First, the SVD analysis found that the global trade network exhibited a hierarchical core-periphery structure in which countries occupied dominant positions vis-à-vis other countries. Additionally, results from chapter 2 highlight the stability of this hierarchical core-periphery structure to the impact of the 2008-09 crisis. Second, analysis of mobility demonstrated that few peripheral countries were able to substantially mobilize up the core-periphery structure. This reflects the constraining nature of the hierarchy on providing opportunities for peripheral countries to improve their status within the global trade network. Thus, the globalization that has grown throughout the first 17 years of the 21st century was associated with a stable hierarchical

structure of the global trade network. In addition, the impact of the 2008-09 crisis was not associated with any significant structural changes. In general, the processes associated with globalization and the social structure of the global trade network have not significantly reversed economic inequalities between nation-states.

Chapter 3 examined the dynamic interplay between the core-periphery structure of the global trade network and national economic productivity after the 2008-09 crisis. The results provide insights about the validity of this expectation. First, the findings are consistent with the expectation posited by world-system theory that position in the core-periphery structure is a significant predictor of national economic productivity. More importantly, this association was prevalent in the post-crisis period. Second, results from chapter 3 show no significant link between structural mobility and national economic productivity from 2001 to 2017. Future research will reassess measures of mobility to validate the null effect of mobility and national economic productivity. The findings from chapter 3, nevertheless, suggest that a country's structural position in the global trade network was significantly associated with levels of national economic productivity in the post-crisis period. In general, structural inequalities remain a significant mediator of economic productivity and that association remained stable and relevant in the post-crisis period.

Overall, these findings are in line with Cattaneo et al (2010) who found that the 2008-09 crisis did not reverse globalization due to resiliency of global trade networks. The structural features of the global trade network also proved resilient to the impact of the crisis; specifically, the hierarchical nature of the global trading system that has been historically divided between the "core" Global North countries and the "periphery" and "semi-periphery" countries of the Global South. More importantly, these inequalities played a significant role in generating national

economic productivity after the 2008-09 crisis. Thus, the hierarchical nature of the global trade network played a substantial role in post-crisis economic productivity. In sum, the three chapters of this dissertation provided a global perspective on the crisis and its impacts on globalization, inequalities, and national economic productivity.

4.2 Areas for Future Research

The main findings and their implications provide a natural guide to future research, and opportunities to delve deeper into areas that were not explored in this dissertation. In this section, I briefly outline areas for future inquiry based on the main findings of the dissertation.

The Role of Global South-South Trade

In chapter 1, I found that economic globalization continued to expand despite the expectations that the 2008-09 crisis would reverse this long-term trend. These findings were interpreted against the backdrop of the Global South-South trade that was noticeable throughout the period of the 2008-09 crisis. However, in this dissertation I did not directly test how much this increasing density observed throughout the period of the crisis was attributed to this growing Global South-South trade. In other words, I would seek to answer how much of global trade is being concentrated in Global South-South trade? Given the data I constructed, future research could partition different trade matrices based on geographical regions and cultural similarities (e.g., similarities in colonial histories, languages, political systems, etc.) to provide a more nuanced examination of Global South-South trade and economic globalization in the 21st century.

Model Refinement

While the results provided an extensive examination of the interplay between the structure of the global trade network and national economic productivity throughout the period

of the 2008-09, certain limitations within the regression modeling open areas for further refinement of variables and modeling. For instance, the use of change in rank order as a measure of structural mobility produced null results. Would a different measure of structural mobility produce different results? Future research will refine the variables for mobility by considering year-to-year change within each of the two dimensions of coreness (export and import).

In addition, future research will use life expectancy as a different dependent variable for national development. Life expectancy affects economic growth because of the increasing investment of human capital across an entire population, and higher life expectancy is expected to generate higher returns on human capital (He and Li 2020). This offers an avenue to assess the interplay between the social structure of the global trade network and development in human capital during a period of global economic crisis. In additional, the modeling approaches of chapter 3, while still requiring refinement, nevertheless afford avenues to conduct robust causal analyses of a crisis' impact on life expectancy. This type of analysis would contribute to my current comprehensive examination of a global economic crisis' impact on nation-states by accounting for aspects of national development that are not captured in conventional measures of economic productivity (e.g., GDP per Capita).

In addition, while the three empirical chapters of this dissertation provided strong evidence that the 2008-09 crisis had a minimal impact on the social structure of the global trade network, future research will develop a stronger modeling approach to directly test a null hypothesis of change across pre- and post-crisis periods. Another limitation of this study was the use of valued data to measure and model network connectivity and multilateralism. While I did use a conservative threshold to consider all relations within the global trade network, future analyses will consider, for instance, using a relative weighting (such as GDP per capita) and

alternative thresholds of dichotomization to test the robustness and validity of my original findings.

Examining Global Value Chains and Cross-Case Comparisons

One other area for future exploration is to examine specific global value chains (GVCs) that give a more granular analysis of the relationship between the crisis and its impact on specific areas of the global trade network. The use of aggregate trade data offered analytical leverage to examine as much of the entire global trade system as possible. Since the use of aggregate trade data did not discriminate countries due their absence in the involvement of certain global value chains, it allowed for a comprehensive and exhaustive examination of how the world economic network adapted to the impact of a *global* economic crisis. Nevertheless, this dissertation developed a launching pad for exploration of the impact of the 2008-09 global economic crisis on specific industries.

There is an additional advantage of marrying the methodological approaches of this dissertation with data of global value chain of specific industries; it would permit a cross-case comparison of the impact of different types of crises on the global trade network. For instance, the challenge of comparing the impact of the current Covid-19 pandemic with the impact of the 2008-09 crisis is that they are vastly different crises. The 2008-09 crisis was a financial crisis that led to a shift in global demand for goods - growing demand in the Global South and a collapse demand in the Global North – that occurred alongside a consolidation in the production of certain global commodities across the Global South, which created both new opportunities and challenges for economic development (see Cattaneo et al. 2010). However, the current global economic crisis (2020-present) was caused by a global pandemic that forced many national economies into lockdowns and caused widespread supply bottlenecks that weighed heavy on

productivity in the world economy (World Bank 2022). Moreover, emerging economies and smaller developing countries are expected to experience weaker economic growth compared to those of advanced economies because of slower vaccination progress, constrained policy responses, and the lasting impact of the Covid-19 pandemic on the health care infrastructures of different countries. Thus, we would expect vastly different outcomes if we compared the impacts of these crises alongside each other, but to fully capture the cross-case complexities requires nuanced trade data across individual industries, or global value chains. In turn, future research will collect and analyze global trade data from the United Nations Commodity Trade Database (UN Comtrade) from 2000 to 2021 to cross-examine the impacts of these crises on the entire global trading system and the world economy in general, and how these impacts affected national economic development.

4.3 Final Remarks

In sum, this dissertation speaks to the value of social network methods in identifying not only structural inequalities at the global level of the world economy but also examining how the global trade network adapted to the 2008-09 global economic crisis. The dissertation also contributes to the study of economic globalization by illustrating the perseverance of connectivity and multilateralism that has grown rapidly over the past five decades, and the role of connectivity and multilateralism in shaping the global trade network into a hierarchical structure. An additional contribution is empirically showing the resiliency of economic globalization and structural inequalities to the impact of a severe global economic crisis. In turn, this study contributes to the sociology of global political economy by providing a foundation for future research on other global economic crises.

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APPENDIX A:
FULL TABLES OF SVD MEASUREMENTS OF CORE-PERIPHERY STATUS

Table A.1 *SVD Measures of Import-Coreness (Sorted by 'Rank in 2011' in Descending Order)*

	Country	Region	2007	2011	Rank in 2007	Rank in 2011	Rank Diff +/-
1	United States	North America	12.128	11.806	191	191	0
2	China	Asia	11.711	11.783	189	190	1
3	Germany	Europe	11.851	11.455	190	189	-1
4	United Kingdom	Europe	11.597	11.261	187	188	1
5	France	Europe	11.6	11.233	188	187	-1
6	Netherlands	Europe	11.546	11.229	186	186	0
7	Italy	Europe	11.406	11.134	185	185	0
8	Japan	Asia	11.21	10.982	184	184	0
9	India	Asia	11.134	10.938	181	183	2
10	Spain	Europe	11.184	10.917	183	182	-1
11	Belgium	Europe	11.173	10.891	182	181	-1
12	Korea, South	Asia	10.726	10.806	179	180	1
13	Canada	North America	10.857	10.645	180	179	-1
14	Turkey	Middle East & North Africa	10.474	10.487	178	178	0
15	Switzerland	Europe	10.295	10.484	177	177	0
16	Russian Federation	Former Soviet States	10.218	10.328	175	176	1
17	Singapore	Asia	9.024	10.286	153	175	22
18	United Arab Emirates	Middle East & North Africa	10.071	10.277	172	174	2
19	Mexico	Latin America & the Caribbean	10.244	10.101	176	173	-3
20	Australia	Oceania	10.213	10.023	174	172	-2
21	Hong Kong	Asia	10.1	10.016	173	171	-2
22	Brazil	Latin America & the Caribbean	10.005	9.958	171	170	-1
23	South Africa	Sub-Saharan Africa	9.083	9.918	157	169	12
24	Indonesia	Asia	9.836	9.916	167	168	1
25	Malaysia	Asia	9.951	9.845	169	167	-2
26	Poland	Former Soviet States	9.835	9.809	166	166	0
27	Thailand	Asia	9.814	9.806	165	165	0
28	Sweden	Europe	10	9.733	170	164	-6
29	Saudi Arabia	Middle East & North Africa	9.481	9.698	160	163	3

30	Denmark	Europe	9.779	9.576	164	162	-2
31	Portugal	Europe	9.747	9.489	163	161	-2
32	Ukraine	Former Soviet States	9.196	9.413	158	160	2
33	Austria	Europe	9.718	9.26	162	159	-3
34	Greece	Europe	9.865	9.196	168	158	-10
35	Egypt	Middle East & North Africa	9.37	9.152	159	157	-2
36	Norway	Europe	9.512	9.136	161	156	-5
37	Pakistan	Asia	9.082	8.962	156	155	-1
38	Czech Republic	Former Soviet States	9.073	8.929	154	154	0
39	Ireland	Europe	8.992	8.844	152	153	1
40	New Zealand	Oceania	8.955	8.829	151	152	1
41	Morocco	Middle East & North Africa	8.815	8.774	147	151	4
42	Lebanon	Middle East & North Africa	8.857	8.767	149	150	1
43	Finland	Europe	9.076	8.766	155	149	-6
44	Colombia	Latin America & the Caribbean	8.631	8.757	141	148	7
45	Romania	Former Soviet States	8.845	8.742	148	147	-1
46	Algeria	Middle East & North Africa	8.773	8.73	145	146	1
47	Kuwait	Middle East & North Africa	8.65	8.671	142	145	3
48	Nigeria	Sub-Saharan Africa	7.864	8.574	126	144	18
49	Argentina	Latin America & the Caribbean	8.179	8.555	137	143	6
50	Serbia and Montenegro	Europe	8.684	8.513	144	142	-2
51	Kazakhstan	Former Soviet States	8.316	8.456	139	141	2
52	Chile	Latin America & the Caribbean	8.135	8.43	135	140	5
53	Angola	Sub-Saharan Africa	8.809	8.397	146	139	-7
54	Croatia	Europe	8.903	8.395	150	138	-12
55	Belarus	Former Soviet States	8.116	8.352	134	137	3
56	Hungary	Former Soviet States	8.684	8.337	144	136	-8
57	Bahrain	Middle East & North Africa	6.834	8.282	98	135	37
58	Philippines	Asia	8.006	8.234	130	134	4
59	Peru	Latin America & the Caribbean	8.104	8.227	133	133	0

60	Ghana	Sub-Saharan Africa	7.975	8.192	129	132	3
61	Bulgaria	Former Soviet States	8.38	8.18	140	131	-9
62	Tunisia	Middle East & North Africa	8.141	8.17	136	130	-6
63	Qatar	Middle East & North Africa	7.974	7.998	128	129	1
64	Slovenia	Europe	7.879	7.953	127	128	1
65	Jordan	Middle East & North Africa	7.708	7.866	121	127	6
66	Kenya	Sub-Saharan Africa	7.81	7.816	123	126	3
67	Sri Lanka	Asia	7.176	7.801	107	125	18
68	Slovak Republic	Former Soviet States	8.082	7.733	132	124	-8
69	Venezuela	Latin America & the Caribbean	8.286	7.733	138	124	-14
70	Tanzania	Sub-Saharan Africa	8.018	7.701	131	122	-9
71	Bosnia and Herzegovina	Europe	7.832	7.644	124	121	-3
72	Lithuania	Europe	7.531	7.626	116	120	4
73	Costa Rica	Latin America & the Caribbean	7.663	7.612	118	119	1
74	Mauritius	Sub-Saharan Africa	7.684	7.585	120	118	-2
75	Mozambique	Sub-Saharan Africa	4.784	7.542	40	117	77
76	Senegal	Sub-Saharan Africa	7.254	7.512	111	116	5
77	Ecuador	Latin America & the Caribbean	7.153	7.505	106	115	9
78	Trinidad and Tobago	Latin America & the Caribbean	7.361	7.408	114	114	0
79	Bangladesh	Asia	7.245	7.406	110	113	3
80	Ethiopia	Sub-Saharan Africa	7.682	7.403	119	112	-7
81	Dominican Republic	Latin America & the Caribbean	7.768	7.397	122	111	-11
82	Congo, DR	Sub-Saharan Africa	7.356	7.366	113	110	-3
83	Uruguay	Latin America & the Caribbean	6.764	7.318	97	109	12
84	North Macedonia	Europe	7.594	7.307	117	108	-9
85	Cameroon	Sub-Saharan Africa	7.474	7.157	115	107	-8
86	Oman	Middle East & North Africa	6.891	7.112	101	106	5
87	Israel	Middle East & North Africa	7.317	7.105	112	105	-7
88	Zambia	Sub-Saharan Africa	6.363	7.032	82	104	22
89	Cyprus	Middle East & North Africa	7.849	7.013	125	103	-22
90	Latvia	Europe	6.757	6.974	96	102	6
91	Albania	Europe	7.004	6.972	104	101	-3
92	Iran	Asia	7.201	6.949	109	100	-9

93	Libya	Middle East & North Africa	7.187	6.938	108	99	-9
94	Azerbaijan	Middle East & North Africa	6.584	6.912	87	98	11
95	Bolivia	Latin America & the Caribbean	6.837	6.901	99	97	-2
96	Iceland	Europe	6.866	6.891	100	96	-4
97	Malta	Europe	6.942	6.848	103	95	-8
98	Iraq	Middle East & North Africa	6.618	6.845	88	94	6
99	Moldova	Former Soviet States	6.741	6.804	95	93	-2
100	Benin	Sub-Saharan Africa	6.274	6.763	77	92	15
101	Cuba	Latin America & the Caribbean	6.91	6.753	102	91	-11
102	Yemen	Middle East & North Africa	7.105	6.648	105	90	-15
103	Estonia	Europe	6.739	6.635	94	89	-5
104	Georgia	Middle East & North Africa	6.517	6.608	86	88	2
105	Guatemala	Latin America & the Caribbean	6.686	6.606	92	87	-5
106	Luxembourg	Europe	6.686	6.594	92	86	-6
107	Madagascar	Sub-Saharan Africa	6.181	6.59	75	85	10
108	Mauritania	Sub-Saharan Africa	4.976	6.545	47	84	37
109	El Salvador	Latin America & the Caribbean	6.691	6.479	93	83	-10
110	Gabon	Sub-Saharan Africa	6.515	6.475	85	82	-3
111	Guinea	Sub-Saharan Africa	6.487	6.451	84	81	-3
112	Rwanda	Sub-Saharan Africa	6.326	6.425	80	80	0
113	Paraguay	Latin America & the Caribbean	5.957	6.373	70	79	9
114	Mongolia	Asia	5.368	6.347	59	78	19
115	Mali	Sub-Saharan Africa	6.279	6.32	78	77	-1
116	Togo	Sub-Saharan Africa	6.18	6.302	74	76	2
117	Malawi	Sub-Saharan Africa	5.459	6.291	62	75	13
118	Nepal	Asia	6.296	6.287	79	74	-5
119	Barbados	Latin America & the Caribbean	6.444	6.27	83	73	-10
120	Kyrgyzstan	Former Soviet States	6.036	6.185	73	72	-1
121	Burkina Faso	Sub-Saharan Africa	6.633	6.175	89	71	-18
122	Niger	Sub-Saharan Africa	6.273	6.161	76	70	-6
123	Namibia	Sub-Saharan Africa	5.787	6.024	69	69	0
124	Jamaica	Latin America & the Caribbean	6.033	5.936	72	68	-4
125	Honduras	Latin America & the Caribbean	6.34	5.926	81	67	-14

126	Seychelles	Sub-Saharan Africa	6.647	5.911	90	66	-24
127	Uzbekistan	Former Soviet States	5.96	5.86	71	65	-6
128	Nicaragua	Latin America & the Caribbean	5.725	5.666	67	64	-3
129	Guyana	Latin America & the Caribbean	5.333	5.604	58	63	5
130	Panama	Oceania	5.152	5.588	52	62	10
131	Vietnam	Asia	5.272	5.573	55	61	6
132	Netherlands Antilles	Latin America & the Caribbean	5.687	5.541	66	60	-6
133	Uganda	Sub-Saharan Africa	5.676	5.532	65	59	-6
134	Fiji	Oceania	5.229	5.482	54	58	4
135	Zimbabwe	Sub-Saharan Africa	5.413	5.439	60	57	-3
136	Myanmar	Asia	5.005	5.367	48	56	8
137	Botswana	Sub-Saharan Africa	5.774	5.31	68	55	-13
138	Cambodia	Asia	4.882	5.204	44	54	10
139	St Vincent and the Grenadines	Latin America & the Caribbean	5.567	5.139	64	53	-11
140	Brunei	Asia	5.43	5.133	61	52	-9
141	Tajikistan	Former Soviet States	5.081	5.102	51	51	0
142	Sudan	Middle East & North Africa	5.278	5.097	56	50	-6
143	Djibouti	Sub-Saharan Africa	5.499	5.047	63	49	-14
144	Gambia	Sub-Saharan Africa	3.728	5.031	24	48	24
145	Maldives	Asia	4.654	5.016	35	47	12
146	Burundi	Sub-Saharan Africa	2.332	4.929	12	46	34
147	Sierra Leone	Sub-Saharan Africa	4.852	4.92	41	45	4
148	Antigua and Barbuda	Latin America & the Caribbean	5.318	4.907	57	44	-13
149	Haiti	Latin America & the Caribbean	4.86	4.838	42	43	1
150	Suriname	Latin America & the Caribbean	4.879	4.824	43	42	-1
151	Greenland	North America	5.202	4.807	53	41	-12
152	Liberia	Sub-Saharan Africa	5.021	4.797	49	40	-9
153	Turkmenistan	Former Soviet States	4.743	4.749	39	39	0
154	Grenada	Latin America & the Caribbean	5.073	4.726	50	38	-12
155	Chad	Sub-Saharan Africa	4.522	4.725	33	37	4
156	Equatorial Guinea	Sub-Saharan Africa	4.656	4.699	36	36	0
157	Bahamas	Latin America & the Caribbean	3.487	4.642	23	35	12
158	Belize	Former Soviet States	4.967	4.607	46	34	-12

159	Cabo Verde	Sub-Saharan Africa	4.713	4.545	38	33	-5
160	Korea, North	Asia	4.899	4.495	45	32	-13
161	Papua New Guinea	Oceania	4.165	4.464	29	31	2
162	Eswatini	Sub-Saharan Africa	4.296	4.356	31	30	-1
163	St Kitts and Nevis	Latin America & the Caribbean	4.551	4.151	34	29	-5
164	St Lucia	Latin America & the Caribbean	4.685	4.138	37	28	-9
165	Eritrea	Sub-Saharan Africa	4.376	4.043	32	27	-5
166	Laos	Asia	3.831	3.961	26	26	0
167	Somalia	Sub-Saharan Africa	3.371	3.946	22	25	3
168	Vanuatu	Oceania	3.84	3.851	27	24	-3
169	Dominica	Latin America & the Caribbean	4.153	3.801	28	23	-5
170	Lesotho	Sub-Saharan Africa	1.268	3.634	4	22	18
171	Central African Republic	Sub-Saharan Africa	4.193	3.62	30	21	-9
172	Bhutan	Asia	3.002	3.166	16	20	4
173	Tonga	Oceania	2.818	3.112	15	19	4
174	Comoros	Sub-Saharan Africa	3.316	3.008	21	18	-3
175	Guinea-Bissau	Sub-Saharan Africa	3.066	2.967	18	17	-1
176	Timor-Leste	Asia	3.002	2.841	16	16	0
177	Syria	Middle East & North Africa	3.262	2.594	19	15	-4
178	Solomon Islands	Oceania	2.425	2.576	14	14	0
179	Palau	Oceania	2.143	2.465	10	13	3
180	Samoa	Oceania	3.269	2.419	20	12	-8
181	Sao Tome & Principe	Sub-Saharan Africa	2.393	2.37	13	11	-2
182	Kiribati	Oceania	1.788	2.368	7	10	3
183	Micronesia	Oceania	2.194	2.284	11	9	-2
184	San Marino	Europe	1.992	2.012	9	8	-1
185	Marshall Islands	Oceania	1.704	1.845	6	7	1
186	Nauru	Oceania	1.851	1.766	8	6	-2
187	Tuvalu	Oceania	1.478	1.337	5	5	0
188	Afghanistan	Asia	3.831	0.608	26	4	-22
189	Armenia	Middle East & North Africa	0	0	2	2	0
190	Congo, Republic of	Sub-Saharan Africa	0	0	2	2	0
191	Ivory Coast	Sub-Saharan Africa	0	0	2	2	0

Table A.2 *SVD Measures of Export-Coreness (Sorted by 'Rank in 2011' in Descending Order)*

	Country	Region	U - 2007	U - 2011	Rank in 2007	Rank in 2011	Rank Diff +/-
1	China	Asia	12.634	12.431	191	191	0
2	United States	North America	12.511	12.098	190	190	0
3	Germany	Europe	12.255	11.93	189	189	0
4	France	Europe	12.045	11.621	188	188	0
5	Italy	Europe	11.881	11.539	186	187	1
6	Japan	Asia	11.974	11.463	187	186	-1
7	India	Asia	11.561	11.41	183	185	2
8	United Kingdom	Europe	11.692	11.409	184	184	0
9	Netherlands	Europe	11.697	11.33	185	183	-2
10	Korea, South	Asia	11.394	11.075	182	182	0
11	Belgium	Europe	11.342	11.065	181	181	0
12	Spain	Europe	11.244	10.978	179	180	1
13	Brazil	Latin America & the Caribbean	11.303	10.968	180	179	-1
14	Switzerland	Europe	11.196	10.882	178	178	0
15	Thailand	Asia	11.184	10.881	177	177	0
16	Turkey	Middle East & North Africa	10.923	10.857	173	176	3
17	Malaysia	Asia	11.044	10.744	176	175	-1
18	Canada	North America	11.038	10.648	174	174	0
19	Sweden	Europe	11.04	10.625	175	173	-2
20	Singapore	Asia	10.476	10.545	167	172	5
21	Indonesia	Asia	10.655	10.53	170	171	1
22	Russian Federation	Former Soviet States	10.694	10.499	172	170	-2
23	Denmark	Europe	10.682	10.422	171	169	-2
24	South Africa	Sub-Saharan Africa	10.376	10.266	163	168	5
25	Austria	Europe	10.559	10.224	169	167	-2
26	Australia	Oceania	10.548	10.196	168	166	-2
27	Poland	Former Soviet States	10.198	10.165	162	165	3
28	United Arab Emirates	Middle East & North Africa	10.009	10.087	160	164	4
29	Ireland	Europe	10.407	10.074	165	163	-2
30	Hong Kong	Asia	10.411	10.023	166	162	-4
31	Vietnam	Asia	9.971	9.988	158	161	3
32	Finland	Europe	10.397	9.97	164	160	-4
33	Argentina	Latin America & the Caribbean	10.182	9.89	161	159	-2
34	Saudi Arabia	Middle East & North Africa	9.652	9.876	152	158	6
35	Mexico	Latin America & the Caribbean	9.871	9.866	157	157	0
36	Portugal	Europe	9.745	9.72	154	156	2

37	Norway	Europe	9.974	9.7	159	155	-4
38	Czech Republic	Former Soviet States	9.564	9.693	149	154	5
39	Ukraine	Former Soviet States	9.806	9.677	156	153	-3
40	Hungary	Former Soviet States	9.692	9.504	153	152	-1
41	Pakistan	Asia	9.786	9.499	155	151	-4
42	Egypt	Middle East & North Africa	9.567	9.453	150	150	0
43	New Zealand	Oceania	9.573	9.36	151	149	-2
44	Romania	Former Soviet States	9.176	9.352	146	148	2
45	Greece	Europe	9.274	9.273	148	147	-1
46	Chile	Latin America & the Caribbean	9.233	9.187	147	146	-1
47	Philippines	Asia	9.1	9.168	144	145	1
48	Bulgaria	Former Soviet States	9.131	9.12	145	144	-1
49	Morocco	Middle East & North Africa	8.627	8.883	139	143	4
50	Bangladesh	Asia	8.612	8.643	138	142	4
51	Sri Lanka	Asia	8.692	8.596	141	141	0
52	Israel	Middle East & North Africa	8.828	8.541	143	140	-3
53	Lithuania	Europe	8.122	8.535	131	138	7
54	Slovak Republic	Former Soviet States	8.698	8.535	142	138	-4
55	Colombia	Latin America & the Caribbean	8.682	8.474	140	137	-3
56	Slovenia	Europe	8.31	8.424	135	136	1
57	Peru	Latin America & the Caribbean	8.437	8.419	136	135	-1
58	Qatar	Middle East & North Africa	7.54	8.395	120	134	14
59	Tunisia	Middle East & North Africa	8.163	8.334	132	133	1
60	Luxembourg	Europe	8.242	8.227	134	132	-2
61	Uruguay	Latin America & the Caribbean	8.234	8.038	133	131	-2
62	Estonia	Europe	7.483	7.99	118	130	12
63	Oman	Middle East & North Africa	7.452	7.987	116	129	13
64	Ecuador	Latin America & the Caribbean	8.016	7.961	129	128	-1
65	Latvia	Europe	7.647	7.918	124	127	3
66	Cyprus	Middle East & North Africa	8.042	7.881	130	126	-4
67	Iran	Asia	8.583	7.871	137	125	-12
68	Costa Rica	Latin America & the Caribbean	7.716	7.853	126	124	-2
69	Kenya	Sub-Saharan Africa	7.75	7.753	127	123	-4
70	Nigeria	Sub-Saharan Africa	7.633	7.749	122	122	0
71	Lebanon	Middle East & North Africa	7.8	7.727	128	121	-7
72	Belarus	Former Soviet States	7.062	7.685	109	120	11

73	Croatia	Europe	7.644	7.667	123	119	-4
74	Jordan	Middle East & North Africa	7.578	7.642	121	118	-3
75	Malta	Europe	7.651	7.579	125	117	-8
76	Kuwait	Middle East & North Africa	7.395	7.569	114	116	2
77	Cambodia	Asia	6.679	7.476	100	115	15
78	Ghana	Sub-Saharan Africa	7.106	7.473	111	114	3
79	C√¥te d'Ivoire	Sub-Saharan Africa	7.461	7.38	117	113	-4
80	Panama	Oceania	7.404	7.374	115	112	-3
81	Guatemala	Latin America & the Caribbean	7.105	7.332	110	111	1
82	Bahrain	Middle East & North Africa	7.004	7.116	107	110	3
83	Iceland	Europe	7.19	7.054	112	109	-3
84	Mauritius	Sub-Saharan Africa	6.824	7.045	106	108	2
85	Venezuela	Latin America & the Caribbean	7.485	6.992	119	107	-12
86	Tanzania	Sub-Saharan Africa	7.03	6.918	108	106	-2
87	Algeria	Middle East & North Africa	6.782	6.917	103	105	2
88	Cameroon	Sub-Saharan Africa	6.588	6.904	99	104	5
89	Honduras	Latin America & the Caribbean	6.743	6.872	101	103	2
90	Dominican Republic	Latin America & the Caribbean	6.807	6.832	104	102	-2
91	Kazakhstan	Former Soviet States	6.753	6.805	102	101	-1
92	Serbia and Montenegro	Europe	6.092	6.704	94	100	6
93	Paraguay	Latin America & the Caribbean	6.085	6.621	93	99	6
94	Cuba	Latin America & the Caribbean	6.809	6.606	105	98	-7
95	Ethiopia	Sub-Saharan Africa	6.202	6.508	96	97	1
96	Georgia	Middle East & North Africa	6.322	6.495	98	96	-2
97	Bosnia and Herzegovina	Europe	5.91	6.454	85	95	10
98	Senegal	Sub-Saharan Africa	6.145	6.418	95	94	-1
99	Zimbabwe	Sub-Saharan Africa	5.918	6.375	86	93	7
100	Trinidad and Tobago	Latin America & the Caribbean	6.241	6.322	97	92	-5
101	Madagascar	Sub-Saharan Africa	5.938	6.313	87	91	4
102	Eswatini	Sub-Saharan Africa	6.034	6.267	89	90	1
103	Namibia	Sub-Saharan Africa	6.051	6.267	90	90	0
104	Uganda	Sub-Saharan Africa	5.826	6.259	81	88	7
105	Syria	Middle East & North Africa	7.231	6.093	113	87	-26
106	Myanmar	Asia	6.058	6.009	91	86	-5
107	Sudan	Middle East & North Africa	3.656	5.969	34	85	51
108	Mozambique	Sub-Saharan Africa	5.409	5.956	75	84	9

109	Jamaica	Latin America & the Caribbean	5.867	5.954	83	83	0
110	Nicaragua	Latin America & the Caribbean	5.375	5.95	74	82	8
111	Albania	Europe	5.318	5.846	71	81	10
112	Azerbaijan	Middle East & North Africa	5.553	5.816	79	80	1
113	North Macedonia	Europe	5.374	5.811	73	79	6
114	Korea, North	Asia	6.07	5.77	92	78	-14
115	Gabon	Sub-Saharan Africa	5.47	5.697	76	77	1
116	Moldova	Former Soviet States	5.529	5.694	77	76	-1
117	El Salvador	Latin America & the Caribbean	5.987	5.603	88	74	-14
118	Malawi	Sub-Saharan Africa	5.751	5.603	80	74	-6
119	Congo, Republic of	Sub-Saharan Africa	5.533	5.601	78	73	-5
120	Libya	Middle East & North Africa	5.835	5.562	82	72	-10
121	Bolivia	Latin America & the Caribbean	5.89	5.527	84	71	-13
122	Zambia	Sub-Saharan Africa	5.358	5.486	72	70	-2
123	Mauritania	Sub-Saharan Africa	5.12	5.399	66	69	3
124	Iraq	Middle East & North Africa	5.001	5.324	63	68	5
125	Bahamas	Latin America & the Caribbean	5.219	5.298	69	67	-2
126	Nepal	Asia	5.235	5.233	70	66	-4
127	Belize	Former Soviet States	4.432	5.183	50	65	15
128	Afghanistan	Asia	4.928	5.181	61	64	3
129	Angola	Sub-Saharan Africa	4.812	5.181	59	64	5
130	Uzbekistan	Former Soviet States	5.047	5.143	65	62	-3
131	Mali	Sub-Saharan Africa	4.845	5.132	60	61	1
132	Sierra Leone	Sub-Saharan Africa	4.933	5.008	62	60	-2
133	Guinea	Sub-Saharan Africa	5.146	5.002	67	59	-8
134	Yemen	Middle East & North Africa	5.017	4.995	64	58	-6
135	Armenia	Middle East & North Africa	4.714	4.941	56	57	1
136	Congo, DR	Sub-Saharan Africa	4.774	4.925	58	56	-2
137	Seychelles	Sub-Saharan Africa	4.761	4.898	57	55	-2
138	Laos	Asia	4.497	4.838	51	54	3
139	Barbados	Latin America & the Caribbean	4.583	4.807	54	53	-1
140	Liberia	Sub-Saharan Africa	4.621	4.789	55	52	-3
141	Haiti	Latin America & the Caribbean	4.257	4.654	47	51	4
142	Togo	Sub-Saharan Africa	4.555	4.647	53	50	-3
143	Suriname	Latin America & the Caribbean	4.358	4.614	48	49	1
144	Guyana	Latin America & the Caribbean	4.548	4.535	52	48	-4

145	Burkina Faso	Sub-Saharan Africa	4.216	4.509	46	47	1
146	Kyrgyzstan	Former Soviet States	4.014	4.478	41	46	5
147	Benin	Sub-Saharan Africa	3.915	4.384	38	45	7
148	Papua New Guinea	Oceania	4.366	4.379	49	44	-5
149	Niger	Sub-Saharan Africa	4.113	4.263	44	43	-1
150	Turkmenistan	Former Soviet States	4.027	4.117	42	42	0
151	Netherlands Antilles	Latin America & the Caribbean	5.184	4.116	68	41	-27
152	Mongolia	Asia	3.956	4.099	39	40	1
153	Fiji	Oceania	3.726	4.004	36	39	3
154	Antigua and Barbuda	Latin America & the Caribbean	3.614	3.987	33	38	5
155	Dominica	Latin America & the Caribbean	3.991	3.984	40	37	-3
156	Brunei	Asia	4.154	3.942	45	36	-9
157	Botswana	Sub-Saharan Africa	3.663	3.884	35	35	0
158	Central African Republic	Sub-Saharan Africa	3.854	3.799	37	34	-3
159	Tajikistan	Former Soviet States	4.087	3.782	43	33	-10
160	Rwanda	Sub-Saharan Africa	3.602	3.742	32	32	0
161	Djibouti	Sub-Saharan Africa	3.328	3.684	30	31	1
162	Maldives	Asia	3.068	3.581	26	30	4
163	Lesotho	Sub-Saharan Africa	2.725	3.53	21	29	8
164	Gambia	Sub-Saharan Africa	3.253	3.452	28	28	0
165	Equatorial Guinea	Sub-Saharan Africa	3.514	3.368	31	27	-4
166	Chad	Sub-Saharan Africa	3.305	3.358	29	26	-3
167	Burundi	Sub-Saharan Africa	3.103	3.215	27	25	-2
168	Comoros	Sub-Saharan Africa	2.803	3.098	22	24	2
169	Cabo Verde	Sub-Saharan Africa	2.631	3.079	18	23	5
170	St Kitts and Nevis	Latin America & the Caribbean	2.56	2.99	17	22	5
171	Somalia	Sub-Saharan Africa	2.866	2.866	24	21	-3
172	Solomon Islands	Oceania	2.348	2.812	14	20	6
173	Grenada	Latin America & the Caribbean	2.657	2.781	19	19	0
174	Greenland	North America	2.445	2.742	15	18	3
175	Vanuatu	Oceania	2.804	2.626	23	17	-6
176	St Vincent and the Grenadines	Latin America & the Caribbean	2.884	2.594	25	16	-9
177	Eritrea	Sub-Saharan Africa	2.532	2.571	16	15	-1
178	St Lucia	Latin America & the Caribbean	2.701	2.489	20	14	-6
179	Samoa	Oceania	2.255	2.405	12	13	1
180	Bhutan	Asia	1.917	2.377	7	12	5
181	Nauru	Oceania	1.97	2.352	9	11	2
182	Sao Tome & Principe	Sub-Saharan Africa	2.284	2.293	13	10	-3

183	Timor-Leste	Asia	1.941	2.283	8	9	1
184	Guinea-Bissau	Sub-Saharan Africa	2.013	2.225	10	8	-2
185	San Marino	Europe	2.244	2.225	11	8	-3
186	Tonga	Oceania	1.513	1.812	5	6	1
187	Kiribati	Oceania	1.539	1.731	6	5	-1
188	Marshall Islands	Oceania	1.481	1.437	4	4	0
189	Tuvalu	Oceania	1.126	1.293	3	3	0
190	Palau	Oceania	0.807	0.937	2	2	0
191	Micronesia	Oceania	0.561	0.807	1	1	0

Table A.3 *SVD Measures of Symmetrical Coreness (Sorted by 'Rank in 2011' in Descending Order)*

	Country	**Region**	**W - 2007**	**W - 2011**	**Rank in 2007**	**Rank in 2011**	**Rank Diff +/-**
1	China	Asia	37.536	38.629	190	191	1
2	United States	North America	38.89	37.568	191	190	-1
3	Germany	Europe	36.856	35.526	189	189	0
4	France	Europe	35.913	34.302	188	188	0
5	United Kingdom	Europe	34.668	33.667	187	187	0
6	Italy	Europe	33.754	33.256	184	186	2
7	Netherlands	Europe	34.178	33.219	185	185	0
8	Japan	Asia	34.467	32.989	186	184	-2
9	India	Asia	32.927	32.66	183	183	0
10	Korea, South	Asia	30.3	30.982	180	182	2
11	Belgium	Europe	31.371	30.882	182	181	-1
12	Spain	Europe	30.826	30.651	181	180	-1
13	Canada	North America	29.85	28.877	179	179	0
14	Switzerland	Europe	27.805	28.631	178	178	0
15	Turkey	Middle East & North Africa	27.225	28.589	176	177	1
16	Singapore	Asia	20.702	27.973	156	176	20
17	Thailand	Asia	27.074	27.475	175	175	0
18	Brazil	Latin America & the Caribbean	27.047	27.106	174	174	0
19	Malaysia	Asia	27.285	26.631	177	173	-4
20	Indonesia	Asia	25.538	26.623	170	172	2
21	Australia	Oceania	26.592	25.932	173	171	-2
22	South Africa	Sub-Saharan Africa	20.915	25.739	157	170	13
23	United Arab Emirates	Middle East & North Africa	23.554	25.629	165	169	4
24	Sweden	Europe	26.573	25.567	172	168	-4
25	Russian Federation	Former Soviet States	24.823	25.558	168	167	-1
26	Hong Kong	Asia	25.762	25.282	171	166	-5

27	Denmark	Europe	25.166	24.989	169	165	-4
28	Mexico	Latin America & the Caribbean	24.255	24.816	167	164	-3
29	Poland	Former Soviet States	22.981	23.996	164	163	-1
30	Saudi Arabia	Middle East & North Africa	20.486	22.83	154	162	8
31	Austria	Europe	23.925	22.433	166	161	-5
32	Portugal	Europe	22.222	22.279	163	160	-3
33	Ukraine	Former Soviet States	20.117	21.733	152	159	7
34	Pakistan	Asia	21.058	21.506	159	158	-1
35	Ireland	Europe	21.497	21.285	161	157	-4
36	Norway	Europe	21.133	20.504	160	156	-4
37	Finland	Europe	21.548	20.441	162	155	-7
38	New Zealand	Oceania	20.561	20.435	155	154	-1
39	Egypt	Middle East & North Africa	20.194	20.395	153	153	0
40	Greece	Europe	21.003	20.164	158	152	-6
41	Czech Republic	Former Soviet States	18.659	19.883	151	151	0
42	Argentina	Latin America & the Caribbean	17.839	19.235	149	150	1
43	Romania	Former Soviet States	17.254	18.487	148	149	1
44	Morocco	Middle East & North Africa	15.971	17.739	145	148	3
45	Hungary	Former Soviet States	18.034	17.455	150	147	-3
46	Chile	Latin America & the Caribbean	15.727	17.369	144	146	2
47	Philippines	Asia	15.447	17.265	142	145	3
48	Colombia	Latin America & the Caribbean	16.405	17.017	146	144	-2
49	Bulgaria	Former Soviet States	16.577	16.669	147	143	-4
50	Lebanon	Middle East & North Africa	15.593	15.892	143	142	-1
51	Peru	Latin America & the Caribbean	14.512	15.485	140	141	1
52	Tunisia	Middle East & North Africa	13.525	15.355	138	140	2
53	Sri Lanka	Asia	13.04	15.256	133	139	6
54	Nigeria	Sub-Saharan Africa	12.777	14.778	132	138	6
55	Croatia	Europe	14.789	14.677	141	137	-4
56	Kuwait	Middle East & North Africa	13.499	14.57	137	136	-1
57	Slovenia	Europe	13.156	14.401	135	135	0
58	Qatar	Middle East & North Africa	11.838	14.217	124	134	10
59	Lithuania	Europe	11.946	13.941	125	133	8
60	Slovak Republic	Former Soviet States	14.304	13.927	139	132	-7
61	Belarus	Former Soviet States	11.442	13.853	119	131	12
62	Ghana	Sub-Saharan Africa	11.79	13.661	123	130	7
63	Bangladesh	Asia	12.653	13.527	129	129	0
64	Kenya	Sub-Saharan Africa	12.759	13.389	131	128	-3
65	Bahrain	Middle East & North Africa	8.911	13.284	99	127	28

66	Costa Rica	Latin America & the Caribbean	12.45	13.253	128	126	-2
67	Israel	Middle East & North Africa	13.086	12.864	134	125	-9
68	Ecuador	Latin America & the Caribbean	11.257	12.74	118	124	6
69	Algeria	Middle East & North Africa	11.694	12.704	122	123	1
70	Serbia and Montenegro	Europe	11.203	12.614	117	122	5
71	Jordan	Middle East & North Africa	11.495	12.591	121	121	0
72	Uruguay	Latin America & the Caribbean	10.878	12.47	114	120	6
73	Kazakhstan	Former Soviet States	10.88	11.865	115	119	4
74	Mauritius	Sub-Saharan Africa	11.011	11.768	116	118	2
75	Tanzania	Sub-Saharan Africa	12.044	11.656	127	117	-10
76	Cyprus	Middle East & North Africa	13.203	11.649	136	116	-20
77	Oman	Middle East & North Africa	9.609	11.574	107	115	8
78	Latvia	Europe	9.906	11.479	110	114	4
79	Venezuela	Latin America & the Caribbean	12.755	11.375	130	113	-17
80	Dominican Republic	Latin America & the Caribbean	11.473	11.374	120	112	-8
81	Iran	Asia	12.007	11.163	126	111	-15
82	Luxembourg	Europe	10.526	11.147	113	110	-3
83	Senegal	Sub-Saharan Africa	9.481	10.831	103	109	6
84	Trinidad and Tobago	Latin America & the Caribbean	9.734	10.634	109	108	-1
85	Estonia	Europe	9.596	10.626	106	107	1
86	Malta	Europe	10.485	10.611	112	106	-6
87	Cameroon	Sub-Saharan Africa	10.092	10.593	111	105	-6
88	Vietnam	Asia	9.066	10.555	100	104	4
89	Bosnia and Herzegovina	Europe	9.198	10.524	102	103	1
90	Ethiopia	Sub-Saharan Africa	9.49	9.979	104	102	-2
91	Iceland	Europe	9.613	9.938	108	101	-7
92	Mozambique	Sub-Saharan Africa	4.375	9.801	57	100	43
93	Guatemala	Latin America & the Caribbean	9.194	9.652	101	99	-2
94	Cuba	Latin America & the Caribbean	9.514	9.345	105	98	-7
95	Angola	Sub-Saharan Africa	8.568	9.017	98	97	-1
96	North Macedonia	Europe	7.664	8.707	94	96	2
97	Madagascar	Sub-Saharan Africa	6.894	8.588	88	95	7
98	Georgia	Middle East & North Africa	7.666	8.441	95	94	-1
99	Albania	Europe	7.06	8.214	90	93	3
100	Honduras	Latin America & the Caribbean	8.372	8.141	97	92	-5
101	Zambia	Sub-Saharan Africa	6.398	8.12	78	91	13

102	Paraguay	Latin America & the Caribbean	6.39	8.097	77	90	13
103	Panama	Oceania	6.854	7.958	86	89	3
104	Namibia	Sub-Saharan Africa	6.741	7.902	82	88	6
105	Azerbaijan	Middle East & North Africa	6.512	7.714	80	87	7
106	Jamaica	Latin America & the Caribbean	6.973	7.504	89	86	-3
107	Gabon	Sub-Saharan Africa	6.833	7.466	84	85	1
108	Bolivia	Latin America & the Caribbean	7.773	7.461	96	84	-12
109	Congo, DR	Sub-Saharan Africa	7.136	7.448	91	83	-8
110	Moldova	Former Soviet States	6.765	7.362	83	82	-1
111	Mauritania	Sub-Saharan Africa	4.487	7.313	58	81	23
112	Cambodia	Asia	5.619	7.276	68	80	12
113	Malawi	Sub-Saharan Africa	5.766	7.163	69	79	10
114	Libya	Middle East & North Africa	7.582	7.106	92	78	-14
115	El Salvador	Latin America & the Caribbean	7.606	7.063	93	77	-16
116	Zimbabwe	Sub-Saharan Africa	6.09	7.004	74	76	2
117	Mali	Sub-Saharan Africa	5.963	6.938	72	75	3
118	Nepal	Asia	6.459	6.643	79	74	-5
119	Barbados	Latin America & the Caribbean	6.09	6.578	74	73	-1
120	Iraq	Middle East & North Africa	5.601	6.562	67	72	5
121	Uganda	Sub-Saharan Africa	5.842	6.539	71	71	0
122	Guinea	Sub-Saharan Africa	6.521	6.516	81	70	-11
123	Nicaragua	Latin America & the Caribbean	5.478	6.492	66	69	3
124	Myanmar	Asia	5.781	6.419	70	68	-2
125	Yemen	Middle East & North Africa	6.854	6.326	86	67	-19
126	Benin	Sub-Saharan Africa	4.742	6.182	60	66	6
127	Togo	Sub-Saharan Africa	5.368	5.873	65	65	0
128	Seychelles	Sub-Saharan Africa	6.877	5.811	87	64	-23
129	Korea, North	Asia	6.305	5.782	76	63	-13
130	Sudan	Middle East & North Africa	3.27	5.731	38	62	24
131	Eswatini	Sub-Saharan Africa	5.226	5.664	63	61	-2
132	Burkina Faso	Sub-Saharan Africa	5.252	5.502	64	60	-4
133	Niger	Sub-Saharan Africa	5.008	5.286	62	59	-3
134	Uzbekistan	Former Soviet States	4.959	5.17	61	58	-3
135	Kyrgyzstan	Former Soviet States	4.214	5.148	54	57	3
136	Netherlands Antilles	Latin America & the Caribbean	6.155	5.084	75	56	-19
137	Guyana	Latin America & the Caribbean	4.564	5.06	59	55	-4
138	Fiji	Oceania	4.086	4.948	52	54	2

139	Bahamas	Latin America & the Caribbean	3.391	4.9	42	53	11
140	Mongolia	Asia	3.51	4.801	43	52	9
141	Belize	Former Soviet States	4.19	4.733	53	51	-2
142	Rwanda	Sub-Saharan Africa	4.293	4.702	55	50	-5
143	Sierra Leone	Sub-Saharan Africa	4.364	4.626	56	49	-7
144	Suriname	Latin America & the Caribbean	3.893	4.4	49	48	-1
145	Haiti	Latin America & the Caribbean	3.718	4.369	45	47	2
146	Antigua and Barbuda	Latin America & the Caribbean	3.756	4.044	46	46	0
147	Liberia	Sub-Saharan Africa	3.901	4.024	50	45	-5
148	Botswana	Sub-Saharan Africa	3.814	3.749	47	44	-3
149	Brunei	Asia	4.005	3.712	51	43	-8
150	Papua New Guinea	Oceania	3.062	3.625	36	42	6
151	Djibouti	Sub-Saharan Africa	3.296	3.512	40	41	1
152	Gambia	Sub-Saharan Africa	2.134	3.441	25	40	15
153	Tajikistan	Former Soviet States	3.568	3.412	44	39	-5
154	Laos	Asia	2.696	3.216	32	38	6
155	Turkmenistan	Former Soviet States	3.023	3.135	35	37	2
156	Dominica	Latin America & the Caribbean	3.325	3.128	41	36	-5
157	Maldives	Asia	2.158	3.022	26	35	9
158	Burundi	Sub-Saharan Africa	1.108	2.956	18	34	16
159	St Vincent and the Grenadines	Latin America & the Caribbean	3.28	2.887	39	33	-6
160	Grenada	Latin America & the Caribbean	2.697	2.762	33	32	-1
161	Chad	Sub-Saharan Africa	2.511	2.755	30	31	1
162	Syria	Middle East & North Africa	3.822	2.638	48	30	-18
163	Equatorial Guinea	Sub-Saharan Africa	2.65	2.628	31	29	-2
164	Cabo Verde	Sub-Saharan Africa	2.174	2.565	27	28	1
165	St Kitts and Nevis	Latin America & the Caribbean	2.218	2.506	28	27	-1
166	Central African Republic	Sub-Saharan Africa	2.811	2.418	34	26	-8
167	Greenland	North America	2.087	2.223	24	25	1
168	Lesotho	Sub-Saharan Africa	0.519	2.209	9	24	15
169	St Lucia	Latin America & the Caribbean	2.432	2.066	29	23	-6
170	Vanuatu	Oceania	1.879	1.935	22	22	0
171	Somalia	Sub-Saharan Africa	1.557	1.878	20	21	1
172	Eritrea	Sub-Saharan Africa	1.883	1.845	23	20	-3
173	Comoros	Sub-Saharan Africa	1.566	1.578	21	19	-2
174	Solomon Islands	Oceania	0.87	1.25	15	18	3

175	Guinea-Bissau	Sub-Saharan Africa	1.065	1.165	17	17	0
176	Bhutan	Asia	0.853	1.14	13	16	3
177	Tonga	Oceania	0.728	1.09	11	15	4
178	Samoa	Oceania	1.196	1.073	19	14	-5
179	Timor-Leste	Asia	0.867	1.02	14	13	-1
180	Sao Tome & Principe	Sub-Saharan Africa	0.954	1.011	16	12	-4
181	San Marino	Europe	0.745	0.773	12	11	-1
182	Kiribati	Oceania	0.382	0.72	7	10	3
183	Nauru	Oceania	0.566	0.687	10	9	-1
184	Marshall Islands	Oceania	0.425	0.542	8	8	0
185	Afghanistan	Asia	3.096	0.481	37	7	-30
186	Palau	Oceania	0.296	0.385	6	6	0
187	Micronesia	Oceania	0.226	0.373	4	5	1
188	Tuvalu	Oceania	0.258	0.294	5	4	-1
189	Armenia	Middle East & North Africa	0	0	2	2	0
190	Congo, Republic of	Sub-Saharan Africa	0	0	2	2	0
191	Ivory Coast	Sub-Saharan Africa	0	0	2	2	0