Measuring Economic Globalization: Exploring methods to map the changing structure of world trade

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Abstract

This paper is the first in a series of papers centered on an empirical exploration of globalization processes. We seek to understand globalization processes through a structural exploration of changing global transactions of multiple types, beginning with international trade. We believe exploring the structure of multiple transactions over time can provide us with insights into the role and position of multiple entities (states and non-state actors), how these are impacted by globalization processes, and what mechanisms are involved in large scale structural changes. The current study compares three different methodological approaches to world trade analysis— a network based data mining program, social network analysis, and a model we describe as a geometric representation, combining aspects of log-linear analysis with multidimensional scaling and correspondence analysis. We examine and compare changes in the structure of world trade at three time points: 1980, 1990, and 2001. We focus on evaluating methodological approaches that can be used to explore the structure of global trade. In future papers, we will be testing hypotheses derived from world systems theory and competing theories of economic globalization. The study addresses three key questions: 1) What methods can we use to assess the impact of changes associated with economic globalization processes? 2) Do patterns of international trade conform to a core / periphery structure through time? and 3) What other (non-economic) factors impact the structure of world trade? The findings yield some important generalizations. First, the results from three different approaches produced the same general structure. We found that the hierarchical nature of the world-system has been remarkably persistent over time in terms of world system zones but that there are important modifications. The presence of Western countries including the US, Canada and many Western European states in the core has been remarkably consistent. What has changed is the number of Asian countries—including China and the four Asian tigers—that trade at high levels with core members. The pattern suggests a strong triad composed of North America, Europe and Asia form the core. Regional trade agreements of the core members appear to have had a positive impact on the trade growth of member countries individually and relative to overall trade. Finally, several Latin American countries have experienced upward mobility but there has been an increasing peripheralization of African countries.

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OVERVIEW

Introduction:

Interest in the phenomenon we refer to as globalization has continued to rise in the media and scholarly journals since the end of the Cold War and with it, the removal of structural impediments to the spread of global capitalism. Although many researchers recognize that globalization has many dimensions—economic, political, and cultural—economic globalization has dominated the attention of many. This paper is the first in a series of papers centered on an empirical exploration of globalization processes focused on changed global transactions. We begin with an exploration of the changing structure of international trade with a focus on the decade before and after the end of the Cold War.

Our goal is threefold: to begin to examine competing hypotheses about changes in the structure of international trade derived from theories of economic globalization and world systems theory; to compare multiple methodological approaches applied to the study of changing international structures; and to advance both theories and methods used to study globalization processes.

Economic Globalization:

Globalization has been conceived of as a process, an ideology and a phenomenon, primarily economic or cultural with both compromising traditional state boundaries. One school does not see it as a new phenomenon, believing it dates back to the 19th century. Others see it as a more recent phenomenon characterized by increasing political and economic interdependence between states. It is generally agreed, however, that the collapse of the Soviet Union and the "consolidation of capitalism" combined with the rapid spread of the information revolution has generated significant political and economic changes, increasing an interest in defining and understanding this phenomenon.

The range of criteria used to define globalization is as extensive as debates on the central consequences, and includes: the compression of space and time (Manual Castells); the coordination of production on a global scale (global commodity chains literature by Gary Gereffi for example); an increase in technological skills and information flows (Stephen Kobrin); an increase in the "interdependence of national economies in trade, finance and macroeconomic policy" (Robert Gilpin); an "intensification of consciousness of the world as a whole" (Roland Robertson); a "diffusion of practices, values and technology that have an influence on people's lives worldwide" (Martin Albrow); and an increase of "cross-border flows of goods, services, money, people, and information, and culture" (Held et al 1999; Guillen 2000:235-6).

These criteria incorporate material, spatio-temporal, cognitive and structural aspects (Held and McGrew 2000; Mann 2000, 2001, 2004; Tomlinson 1999). Material aspects include "flows of trade, capital and people across the globe…facilitated by different kinds of infrastructure – physical (such as transport or banking systems), normative (such as trade rules) and symbolic (such as English as a lingua franca) – which establish the preconditions for regularized and relatively enduring forms of global interconnectedness" (Held and McGrew 2000:3). The spatio-temporal aspects denote the "stretching of social relations and activities across regions and frontiers" and the consequences of "distant occurrences and developments" domestically and vice versa (Held and McGrew 2000:3). For example, the 1997 East Asian economic crash was felt both regionally and globally. The cognitive aspect of globalization includes an awareness of "the ways in which distant events can affect local fortunes (and vice versa) as well as in public perceptions of shrinking time and geographical space" (Held and McGrew 2000:4). Structural aspects include changes in power networks.

In general, theory has raced ahead of empirical explorations and testing of hypotheses so our understanding of globalization remains limited. The goal of this paper is to empirically examine one aspect of globalization—economic—through a structural analysis of trade data. Although there are many definitions of economic sociology with various indicators posited, we draw from two primary sources. The Handbook of Economic Sociology (Smelser and Swedberg, 2005, **pages?)** defines economic globalization as referring to at least 3 related phenomenon: extensive growth in world trade in the past 50 years; from 5% of world GDP inter-national in 1950 to 17% in 2001; increased expansion and integration of the world's financial markets as both cause and consequence of the increase in trade; and tremendous economic development in Asia, especially Korea, Thailand, Indonesia, Philippines, and now China and India.

The second source is CSGR Globalization Center which has created an Index to measure economic globalization.[1] The index consists of four variables: **trade** (exports plus imports of goods and services as a proportion of GDP—data from the World Bank-World Development Indicators); **FDI** (inflows plus outflows of foreign direct investment as a proportion of GDP—also from the World Bank-World Development Indicators); **Portfolio Investment** (Inflows plus outflows of portfolio investments as a proportion of GDP—from the IMF-International Financial Statistics); and **Income** (Employee compensation paid to non-resident workers and investment income from foreign assets owned by domestic residents plus employee compensation paid to resident workers working abroad and investment income from domestic assets owned by foreign residents, as a proportion of GDP—also obtained from the World Bank-World Development Indicators). Their measure is intended to be complementary to the annual Globalisation Index published by Foreign Policy magazine (see http://www2.warwick.ac.uk/fac/soc/csgr/index/guide/variables/ and Lockwood, 2004). They also use five variables to measure economic inequality. Three variables are used to measure inequality of land distribution: 1) GINI (Gini index of concentration; measures deviation of Lorenz curve from line of equality); 2) FARM (percentage of farmers that own half of the land, beginning with smallest, e.g., if 90%, then 10% of farmers own half of land); and 3) RENT (%age of farm households that rent all of their land). The other two variables are GNPR (gross national product per capita); and LABO (%age of labor force employed in agriculture).

Although we will be incorporating other dimensions of economic globalization in future papers where we examine specific commodities, global commodity chains, case studies and regional studies, this paper will focus on the changing structure of global trade. We believe such a focus will provide insights into competing theories of world divisions from globalization and world systems theory to more delimited processes or divisions (Northernization, trilateralism, regionalization, and internationalization) which vary in their predicted potential to impede or encourage globalization processes. It will also provide insights into changing inequalities and an overview of economic winners and losers in globalization processes. We will review these theories in brief below and

[1] Their measure incorporates three dimensions of globalization: economic, social and political and they have created several indicators to measure each dimension.

then derive some hypotheses which we can examine in our empirical analysis of trade relations.

The Structure of World Trade:

Although some theorists contend that globalization dates to the 19th century, most agree that the dissolution of the Soviet Union has resulted in the universalism of capitalism (some barriers do remain, notably Iran, China and a few other smaller communist countries (Mann 2004; Held and McGrew 2000). Several theorists believe that "capitalist activity is more 'trilateral' than global, being concentrated in the three regions of the advanced or 'global north': Europe, North America and East Asia" (Held and McGrew 2000:139). These 3 areas "contain over 85 percent of world trade, over 90 percent of production in advanced sectors like electronics, plus the headquarters of all but a handful of the top 100 multinationals (including banks)" (Held and McGrew 2000:139). Recent studies confirm that multinational enterprises (MNEs) operate regionally, not globally.[2] Other factors such as ideological power differences are believed to have continual salience on macro-regional variations in economic policy--notably in the retention of social democratic welfare states despite claims to convergence and universal embracement of neoliberal policies (Mann 2002, 2004). Related to this, many theorists argue how much globalization processes are subject to national and international governance.

Although both governance issues and consequences of global capitalism including growing inequalities within nation-states are important, we limit the scope of this study to examining the changing structure of global trade in the decades before and after the end of the Cold War and the dissolution of the Soviet Union. We explore what pattern of trade relations best describes current economic divides—Northernization, trilateralism, regionalization, internationalization or globalization. We also examine traditional world systems theory zones and whether these have been modified in the post-Cold War period. We discuss these in brief below.

Northernization. Mann argues that three waves of economic integration have resulted in what is more accurately called "Northernization" rather than globalization. The first wave of economic development after 1945 involved Southern Europe, Japan and the "Little Tigers of East Asia," transforming "a privileged and fairly integrated 'West' into a privileged and fairly integrated 'North'" (Mann 2004:10). The second wave began in the late 1980s and included China and India with China absorbing over half of the Northern investment into the South. The third wave incorporated much of Asia but also several Eastern European economies (the Czech Republic, Poland and Hungary) and a few South and Central American countries like Chile and Mexico (Mann 2002:3). These countries have not really prospered as a result of integration, however, because of neoliberal policies forced on their economies and because of unequal exchange due to trade rules more favorable to the North. Debt from interest rates has resulted in structural adjustment programs which affect states expenditures, welfare programs, labor market regulation and tariffs, creating at times a negative net economic effect. Mann notes a "third tier" of Southern countries including Sub-Sahara Africa and some Middle Eastern

[2] Recent studies of the 500 largest MNEs found that 320 of the 380 largest firms are regional multinationals with about 80% of sales in their home region of the triad and only 9 operating as key players in each of the triad (Rugman 2005: 20-1).

and South American countries are essentially excluded from economic integration because they are poor credit risks for foreign investment and international trade. He notes that should these countries industrialize they will bring additional global problems such as increased environmental degradation. Integrating them in the global economy, therefore, requires international cooperation and planning.

Trilateralism or "triadization". The "triadization" of the world economy is represented by three core blocs (Europe, the Americas and Asia-Pacific), each with its own center and periphery, and marked by more interdependence within the three blocs than integration between them (Held and McGrew 2000:20). These (Northern) countries "provide over 80% of world production, trade and finance—and over 95% of economic research and development." Mann refers to this structure as "macro-regional trilateralism" resulting in a "Northern" economic hegemony (Mann, 2004:8).

Kenichi Ohmae in his book "Triad Power" goes so far as to say that the triad (defined as US, EU, and Japan) is a geographic space with the following in common: "low macro-economic growth; a similar technological infrastructure; the presence of both capital and knowledge intensive firms in most industries; a relative homogenization of demand (with a convergence of required key product attributes) and protectionist gestures" (Rugman and Verbeke 2004: p. 2). Rugman and Verbeke note that Ohmae did not anticipate the 'broad' triad of today consisting of NAFTA (1994), an expanded EU (25 countries in 2004), and Asia (In 2002, China had a free trade agreement with 10 members of ASEAN; in 2003, India and ASEAN members agreed to a free trade agreement by 2012; and Japan and ASEAN agreed on trade and investment liberalization by 2005 (Rugman and Verbeke 2004: 4). They believe these events will contribute to a deeper intra-regional market penetration but not global integration through multilateral negotiations (Rugman and Verbeke 2004: p. 5). They note that the triad has the three largest markets in the world. It also has a concentration of the world's largest multinational enterprises (MNEs)—430 of the 500 MNEs had corporate headquarters in the core triad regions in 2000 (Rugman and Verbeke 2004: 2).

Regionalization. Regionalization has been conceptualized in many different ways: as trading blocs; as a geo-political division of the world into military-power blocs; and as the development of a regional identity. Economic policies can pave the way to increased regionalization even when there are strong differences among states. For example, the EU began as a political decision by the EC to increase economic homogenization. Bjorn Hettne believes a form of homogenization has occurred at the global level through rules created by the IMF and the World Bank. Similarly, on the political dimension, established Western states have imposed rules for political reform that are tied into economic incentives with significant results. Evidence of this is seen in the increase in the number of democratic states following the Cold War. By 1991, the number of democratic states exceeded the number of non-democratic states for the first time. (Hettne 2000:157).

Hettne believes regionalization takes place at three levels simultaneously: "the structures of the world system as a whole, the level of interregional relations, and the internal pattern of the single region. Changes on the three levels interact, and the relative importance of them differs from one region to another" (Hettne 2000:160). During the Cold War, 'hegemonic regionalism' dominated, reproducing global divisions within regions. The end of the Cold War could result in a multipolar system or a strengthening of US hegemony. He notes that European regionalism is a positive (promoting) and negative (provoking) "trigger of global regionalization" providing a model and taking an active role in promoting regional formations in the Third World. This is a very different model from US bilateralism which discourages regionalism. The more negative side of European regionalism is the threat of regional protectionism as in the case of European agricultural protectionism ("European Fortress") which is blamed for the 1991 GATT negotiations and resulted in efforts by other groups to form a trading bloc. For example the Malaysian prime minister invited Japan "to act as a leader of an East Asian Economic Grouping—later to be called Caucus—which implied "an East and South East Asia superbloc with a Sino-Japanese core" (Hettne 2000:161). There was no response from Japan but it is believed this was left as an open option. The direction these patterns take depends on how international regional change and external relations develop. For example, the Commonwealth of Independent States (CIS) could become a region, Russia could align with the Pacific and Ukraine and Belarus with the West; and Central Asia could join a number of regions.

Thompson agrees that regionalization is a process that can draw states and groups together on the basis of their proximity, and notes the importance of institution building measures driven by political objectives (Thompson 1999:63). The question is whether this will create a more polarized world in terms of trade flows and possibly leading to trade wars or will it help the multilateral liberalization process (Lloyd 1992). Thompson sees it as a 'positive drift from geo-politics towards geo-economics of a competitive world economy' (Thompson 1999:72). Whether regionalization encourages and facilitates economic globalization by providing "a mechanism through which national economies can engage more strategically with global markets" or is an impediment to globalization remains to be seen (Held and McGrew 2000:24).

Internationalization. Held and McGrew note that although links between separate national economies has increased—evidenced by "a concentration of trade, capital and technological flows between the major OECD states"—most of the world has been excluded. They believe that even the OECD states—currently the interconnected economies—represents only a "limited degree of economic and financial integration" better characterized as internationalization (Held and McGrew 2000:19-29).

Globalization. Some theorists cite the newest international division of labor (IDOL) as evidence of globalization. The new IDOL " is constructed around four different positions in the informational/global economy: the producers of high value, based on informational labor; the producers of high volume, based on lower-cost labor; the producers of raw materials, based on natural endowments; and the redundant producer, reduced to devalued labor" (Held and McGrew 2000:268).[3] These positions are not located within countries but "organized in networks and flows, using the technological infrastructure of the informational economy" (Held and McGrew 2000:268). These positions are seen as both creating new patterns of wealth and inequality and replacing the core-periphery model of economic relations (Held and McGrew 2000:26-8).

[3] For additional information on NIDL, see origins in Forbel, Henrichs and Kreye (1980) followed by Ross and Trachte (1990).

World systems theory. There have been many recent studies examining the structure of world economic divisions posited by world systems theory (WST).[4] We will outline some of these below as it is within this tradition that we find most of the studies on global trade. This perspective also incorporates historical changes and other dimensions of political economy central to studies of inequality.

Traditional world system theory posits core, periphery, and semiperiphery states which have power-dependence linkages. The core (comprised of Western Europe, Japan, and North America) dominates global economic networks. Peripheral states (comprised of the majority of less developed states in Latin America, Africa, and Asia) are dependent and disadvantaged relative to the core. These states typically have weak domestic economies and tend to have commodity exports highly concentrated in primary products. They also experience higher levels of poverty, environmental problems, and higher population growth relative to the core, and they are technologically and educationally disadvantaged with significant segments of labor force engaged in agrarian activities. This combination results in economic stagnation and a lack of mobility. The ties they share with the core are asymmetric. Semiperipheral states (comprised of the Middle East, parts of Latin America and Asia) occupy an intermediate position in the global structure and therefore have characteristics of both the core and periphery. They have asymmetric ties to the core but "favorable power asymmetries with the periphery" (Kick and Davis 2001:1563). These states are rapidly industrializing, they exchange finished goods for raw products from the periphery and they are economically dependent on the core through foreign investment. Their citizens are moderately well educated and technically advantaged.

Kick and Davis (2001) modified the traditional WST approach by emphasizing the importance of noneconomic links between states and the world-system structure.[5] They conducted a block model analysis of the world system structure for two periods: 1960-5 and 1970-5, reflecting the postwar colonial era and what they conceive of as the "truly modern world system" respectively (Kick and Davis 2001:1562). They examined 8 different ties reflecting economic, political, military, sociocultural and technological dimensions for 130 states. Their analysis resulted in a world structure that varied from the conventional world system described by Wallerstein, namely that the world economy is just one dimension of several transnational interactions of the world system. These include: "trade flows, bilateral economic aid and assistance treaties, bilateral transportation and communication treaties, bilateral sociocultural treaties, bilateral administrative and diplomatic treaties, political conflicts, armament transfers, and military conflicts" and these economic and noneconomic dimensions reinforce each other (Kick and Davis 2001:1565). For example, the flow of information regarding political, economic and strategic conditions depends on political ties resulting in a reduction of information flows during times of political conflict. Labor, production and marketing were facilitated by sociocultural ties.

[4] For a good review of WST, see Chirot and Hall, 1982; important relevant works include Chase-Dunn, 1980; Chase-Dunn and Grimes, 1995; Chase-Dunn and Hall, 1991; and Chase-Dunn and Brewer, 2000; and Wallerstein, 1974.

[5] Snyder and Kick, 1979, also examined other types of international networks, adding military interventions, diplomatic relations, and conjoint treaty memberships to trade flows, to "empirically ground" the conceptual framework of a world system with a theory of social structure. They built on White, Boorman and Brieger's (1976) block model analyses of the structural aspects of the world economy.

Their study confirmed that the core was comprised of Western industrial countries and these countries dominated the world system in economic, transportation, communications, sociocultural, political and military networks. Members of the core are the primary exporters and importers; they provide central aid, represent a cultural center and they are the focus of communication and world transportation (Kick and Davis 2001:1566-8). Contrary to other studies, they found that in the first time period, the semiperiphery was distinguished by two divisions represented by capitalist and socialist countries. Based on this, they divided the semiperiphery into an upper semiperiphery which they refer to as the semicore, and a lower semiperiphery which they feel represents the true semiperiphery. They further divided the semicore into a socialist and capitalist semicore. The socialist semicore is comprised of Eastern socialist countries—the old socialist bloc—and they found these states maintained strong economic and military ties with their former satellites located in the periphery. The capitalist semicore is comprised of less powerful capitalist states such as Norway. These two systems competed for domination, affecting the economies of states with which they shared ties. The other states in the semiperiphery include advanced lesser developed countries (Kick and Davis 2001:1561).

During the second time period, they found relations between states were consistent with more standard world-system theory. The core was again composed of Western industrial states, and there was a socialist and capitalist semicore; with the remaining states part of the "true" semiperiphery and periphery. This time period revealed "significant transideological trade ties that integrated socialist states into the capitalist world economy" (Kick and Davis 2001:1568). They noted that African states are not integrated into the global economy, and lack ties to states in other positions.

The authors also used OLS regression to examine "differences in trajectories between countries in terms of overall economic well-being" (Kick and Davis 2001: 1570). They found that system position affected aggregate per capita wealth over time (Kick and Davis 2001:1571). The strength of international economic ties impacted domestic (national) economies with countries in the socialist semicore faring the worse in economic growth (because of negative ties to the strong capitalist core) (Kick and Davis 2001:1573). They concluded that networks of cooperation and conflict across economic, political, cultural, social and coercive dimensions bind states together in the world system. The socialist semicore and its allies in the semiperiphery suffered the greatest domestic costs because of their negative relationship with the capitalist core and semicore (Kick and Davis 2001:1574).

Ankie Hoogvelt found a different type of path dependency than the one Kick and Davis describe. He found four legacies from earlier colonial social formation. First, exclusion and anarchy exemplified in sub-Saharan Africa, where post-independent patrimonial states were too weak to create political cohesion or civil society because of ethnic fragmentation created by colonial administration. These weak states remained vulnerable to dependencies created by conditions of colonialism. Second, he found fundamental Islam to be disruptive to the development of a civil society. Third, although state-led developmentalist projects have helped lead a small number of NICs into the global capitalist system, he feels they remain vulnerable to globalization processes unless they can develop regionalization to promote a regional division of labor. Fourth, he found historical resistance to western models of modernity and progress in Latin American has politicized the process of impoverishment and exclusion from the world economy (Held and McGrew, 2000, p. 359).

Hoogvelt uses three key economic indicators to examine the extent of participation of the periphery in the increasing internationalization of the world economy: "world trade figures; the growth and spread of foreign direct investments through multinational corporations; and the expansion of all international capital flows" (Held and McGrew 2000:355). He found evidence of "a modestly thickening participation within the core, the graduation of a small number of peripheral nations with a comparatively small population base to 'core' status" and "a declining economic interaction between core and periphery, both relative to aggregate world trade and relative to total populations participating in the thickening network" (Held and McGrew 2000:356). He concludes that globalization has rearranged the structure of the world order from a pyramid to a three-tier structure composed of concentric circles, all of which cut across national and regional boundaries. The core circle contains the elites of all continents and nations (20 percent of the world population); this circle is contained within a larger more fluid social layer of 20-30 percent of the world population who labor in insecure forms of employment and competing in a cut-throat global market. The third and largest circle contains all of those already excluded from the global system.

Peter Dicken also found that economic processes are "path dependent" as states often become locked into a historical pattern. But he believes that earlier geographical specializations structured around a core, periphery and semi-periphery have been replaced by the "emergence of a *new global division of labor"* evidenced by more complex trade flows illustrating a fragmentation of production processes that cut across national boundaries (Held and McGrew 2000:251). The interaction of state, international organizations and transnational corporations ("TNCs") interact to produce this new division of labor and new geographical clusters of economic activity centered upon global commodity or production chains (Held and McGrew 2000:254-6).

Several recent studies using social network analysis have explored the new global division of labor. Smith and White (1992) applied a newly developed measure of regular equivalence and examined change in the global structure of trade over time. They found the general structure of the world economy posited by WST to be intact. They also found evidence for the new global or international division of labor (NIDL). Kim and Shin (2002) conducted a longitudinal study of international trade networks and found that neoclassical economic theory provided a better explanation for the structure of world trade than WST because of the recent decentralization of trade networks. They found that intra-regional trade ties were stronger than inter-regional ties; that the number of trade partners of countries has increased, and that the overall world trade network has become denser. They did find an unequal integration of countries into the world economy and some support for Wallerstein's claims that countries in the semipheriphery have a unique position in economic cycles.

In a study similar to Smith and Whites's, Mahutga (2006) explored the impact of changes associated with globalization and NIDL on structural inequality in the world economy in the period from 1965 to 2000. He found that unequal levels of processing continue to create structural inequality through the reproduction of a segmented international division of labor. His study also revealed several other important elements of global trade. First, he discovered a high level of structural stability between 1965 and

2000, with the more recent decades demonstrating the most stability. Second, he found that the most important change in the world system occurred with the rise of labor-intensive manufacturing in non-core zones of the core/periphery hierarchy. Third, he found that the former manufactured goods/raw materials dichotomy co-exists with a low value added/high value added dichotomy. Fourth, he found that upward mobility in the world economy was rare through a period that assumed massive restructuring. He did find evidence to indicate upward mobility was possible (South Korea, Singapore and Turkey for example). Fifth, he found that the expansion of neo-liberal trade regulations is associated with less structural change than the period before this policy expansion. Therefore, the processes associated with globalization and the NIDL have not reversed structural inequality despite the ability of a few semi-peripheral countries to move up the value added hierarchy and thereby increase the standard of living within these countries. Finally, his finding that the core countries remain the global winners resonated with Dickens' observation that "there is a hard core of exceptionally poor countries that remains stranded… " (Dicken, 2003: 514).

Summary:

Debates about globalization processes incorporate many of the same concerns of WST, specifically, what is the structure of the world economy, how has it changed over time related to socio-political configurations, and how does the structure of world trade contribute to global inequality. Both traditions concern themselves with how the structure of world trade influences and reshapes local, regional and global political, economic and social systems. The theoretical considerations of both make network analysis uniquely suited to the study of international trade because of the empirical implications for structures of international trade. The complexity of the interrelations between the political, economic and cultural dimensions of states (and other entities such as MNEs, NGOs and IGOs) and the massive amount of data needed to examine each dimension, taxes traditional network methods. Recent studies of global phenomenon (international terror networks as one example) have incorporated data mining techniques with statistical and network methods. Therefore we explore and compare three methodological approaches appropriate to the study of large data sets related to globalization processes.

This paper is the first in a series of papers on globalization processes, and part of a project which asserts the multidimensionality of globalization. We hope to demonstrate how the problem of globalization is an excellent example of the necessary marriage between theory and method, e.g., how the methodological contributions of network theory (and eventually, complexity) can help us derive the theoretical foundation necessary to understand this social phenomenon. We begin with the premise that a structural overview of relations among a variety of entities provides a starting point from which to pursue "deeper analysis." The broader goal of this paper is to develop a structural explanation of economic globalization through an empirical analysis of changing trade patterns. Therefore, the focus of this paper is to examine and compare changes in the structure of world trade at three time points: 1980, 1990, and 2001. The study addresses three key questions: 1) What methods can we use to assess the impact of changes associated with economic globalization processes? 2) Do patterns of international trade conform to a core / periphery structure through time? and 3) What other (non-economic) factors impact the structure of world trade?

Data:

Trade data:

The primary dataset used for this study comes from the World Trade Analyzer (WTA).[6] Countries report their exports and imports to the United Nations using various commodity classification schemes and with varying levels of detail. Statistics Canada then organizes the data. They begin with exports as the base data, estimate missing values through mirror statistics, and, wherever possible, distribute highly aggregated regions or commodity categories to more detailed countries or categories. The end product is a non-symmetrical, square matrix for each year and commodity type which is distributed though World Trade Analyzer, and available by paid subscription. The classification system the World Trade Analyzer uses is SITC rev. 2. Current versions of WTA contain data from 1985 to 2003. The version released in 2001 included data from 1980 to 1999; earlier versions also included data beginning with 1980.

The UN does not report data for Taiwan for political reasons (e.g. China's "One Nation" policy), and often the data for China includes Taiwan's information. The UN Comtrade database incorporates Taiwan as a trading partner by adding it to "Other Asia, not elsewhere specified" (code 490) which could in principle contain trade other than from Taiwan but is generally considered Taiwan. In general, using reporter data to represent Taiwanese trade reasonably matches the data actually reported by Taiwan (although never a perfect match). WTA is presumed to use the Comtrade data directly and do not supplement it with OECD data. Hong Kong re-exports are another problematic reporting area. These issues reflect a need for the ITRB to compile a sifted, documented and transparent set of estimates. Taiwan's reported data is therefore not included in Comtrade; data for Taiwan in the WTA is taken from other countries' reported trade with Taiwan (e.g., "mirror flows").[7]

We used categories for total trade rather than for individual commodities as we are interested in the overall structure of world trade. Regional designations are those used by WTA (same as those for UN Comtrade). To incorporate a dynamic aspect of the changing structure of world trade, we used three different time points—1980, 1990, and 2001—intended to capture the major transformations resulting from the end of the Cold War and the resulting independence of former Soviet satellite countries and other countries. There were 164 countries in 1980 and 1990 and 181 in 2001, for a total of 187 unique countries. In addition, our data mining method incorporated non-country entities comprised of unknown partners and various categories where the final destination was not known. In some instances, it appeared that these might have been ways to get around sanctions such as occurred with South Africa, but this is not documented. We did not feel the need to keep the same set of countries for each year, because it was important to capture major transformations such as the realignment of former Soviet satellite countries with Western states.

Determining Thresholds. The Princeton trade database has over 1.5 million records. Although most of the analyses included subsets of the trade data, graphing the

[6] We used an online version of WTA. There are several academic portals; we accessed the data through Princeton University: http://trademeasures.com:8185/welcomeprinceton.htm.

[7] We thank Ronald Jansen, UN Stats division, and Scudder Smith, WTA, for their help in answering the questions related to preparing the data for analysis.

relationships for large datasets was problematic because of readability. Therefore, we created threshold levels using several different methods.[8] The method we use in this paper separates out all transactions larger than a certain percent of the total traded value, using 1980 percent value as a constant dollar term for 1980, 1990 and 2001. This calculation was done using the following method: First, the total value of trade in a commodity in 1980 was found by adding up all of the \$ values in all cells in a country-by-country matrix. This total, $\$T_{c80}$, is the total value (\$T) for commodity c in 1980. The threshold value we chose was .3% of total trade. The value for 1980 was calculated using the following formula:

$$\$P.3_{c80} = .003 \times \$T_{c80}$$

This is the dollar value of 0.3% of the total trade value in 1980 of commodity c.

Then thresholds for 1990 and 2001 are determined using the CPI inflator by multiplying $\$P.3_{c80}$ by 1.59 for the 1990 value ($\$P.3_{c80\_90}$) and by 2.15 for the 2001 value ($\$P.3_{c80\_01}$). Using the 0.3% threshold produces graphs showing only trade links that are equal to or greater than $\$P.3_{c80}$ in 1980, $\$P.3_{c80\_90}$ in 1990, and $\$P.3_{c80\_01}$ in 2001. Values are rounded-up to the nearest \$1,000 value in each cell to calculate inclusion.

Data Processing. We created two sets of data for NetMap analysis. The first set keeps every country reporting and reported in World Trade Analyzer. The second set aggregates the twelve countries that use the Euro currency: Austria, Belgium, Germany, Spain, Finland, France, Greece, Ireland, Italy, Luxembourg, The Netherlands and Portugal. Belgium and Luxembourg are always aggregated in the WTA data, so the process of aggregating the Euro-12 actually involved adding up only 11 countries. Exports from each country in the world to all of the 11 country units were added to produce a single export value from each country to the newly named Euro-12. Then exports from the 11 country units to every other country in the world were added to produce a single export value from Euro-12 to each country. Trade among the 11 country units in the Euro-12 was excluded. The rational for this second method is that to keep these 12 countries separate masks the pivotal role they play in world trade. Also, because these countries share the same currency, trade among them can be thought of as domestic trade, analogous to goods moving across state lines in the U.S., rather than international trade. For some very particular products, e.g. wine or cheese, grouping these countries may not make as much sense. However, for the majority of products, we argue that this is a useful improvement, allowing for greater clarity in the network structures of trade. We only used this for NetMap analysis, however.

Defining Regional Splits. World Trade Analyzer has a "standard" regional split for countries.[9] We used this WTA regional split and created two other regional splits. The first adds the countries in East Asia and Southeast Asia into one category called "Eastern Asia." The second version does the same thing with Eastern Asia, but then also separates out the NAFTA countries into their own region, and puts the rest of North and Latin America together in a region called "Americas."[10]

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[8] Thresholds were created by Miguel Centeno and Abigail Cooke, Princeton University.

[9] We use WTA regional designations because they are appropriate for this data. There are many other ways to define regions; see Lewis and Wigan, 1997, for a discussion of the theoretical construction of regions.

[10] See Appendices A and B for lists of countries, their abbreviations, WTA regional designations and the key to the world system zones.

Country Attribute and Membership Data:

In addition to looking at the structure of world trade, we explored reasons for both the enduring structure of world trade and changes in trade relationships, including political transformations, memberships in trade treaties and regional groups, and levels of development. Snyder and Kick (1979) and Kick and Davis (2001) found that networks of cooperation and conflict across economic, political, cultural, social and coercive dimensions bind states together in the world system. Therefore, we look at common memberships in international and regional economic, political, cultural and military organizations such as ASEAN, CARICOM, COMECON, EU, FSU, G7, G77, MERCUSOR, and NAFTA to see if these memberships influence the structure of trade. We also look at various economic indicators of states such as GDP per capita to see if states measuring the same on these economic indicators are more likely to trade together. Finally, we examine categorizations such as world systems zones, Huntington's civilizations, and political regime type to see if these influence the structure of trade relations.[11]

Methods:

Several methods are appropriate for studying global economic data. Technological advances and improvements in the generation and collection of data have resulted in multiple large datasets requiring new methods and tools to make sense of them. Data mining or "knowledge discovery" is increasingly used by academics to infer useful information from otherwise unmanageable data sets. Social network methods have also increased in popularity across disciplines as a method to infer structure among a full array of relational data. Mathematical modeling to capture dynamic aspects of change and the complexity inherent in multidimensional relationships have also increased in popularity. We attempt to incorporate these aspects in a model we describe as a geometric representation, combining aspects of log-linear analysis with multidimensional scaling and correspondence analysis.[12] We explore several methods through an analysis of international trade data: a unique data mining program—NetMap, several social network tools and (how to describe exponential distance model). Our goal is both to evaluate different approaches used to analyze large datasets and to "test" the robustness of our findings across methods. In addition, each of the methods has a unique approach to visualization of structural data which we compare and evaluate.

NetMap:

NetMap as a data mining tool. NetMap is a data mining tool, but one that differs from traditional data mining in that it is a network data mining tool. Traditional data mining and analysis tools generally work by statistically summarizing data (Fayyad et al. 1996; Nong 2003; Galloway and Simoff 2005) then observing trends and looking for exceptions (referred to as 'exception detection'). A more narrow conceptualization equates "data mining" with predictive modeling methods. The goal of predictive modeling is to seek a combination of variables that together "predict" some outcome or criterion variable. Several "attributes" of the entities (e.g. people) such as demographics

[11] This data is from Lloyd, 2005.

[12] We are still developing this model but show some preliminary results here.

and behavioral variables, are combined statistically (neural net or regression techniques) to predict the values of an output variable (e.g. likelihood of buying a product). NetMap also differs from traditional data mining in that it integrates the exploration and pattern spotting abilities of the human mind with the processing capabilities of computers to form a powerful knowledge discovery environment. This human-centered approach enables outcomes that go beyond the limits of automated rules-based 'exception detection' discovery processes.

NetMap also differs from the statistically-driven approach of traditional data mining approaches because it goes beyond summarizing data to mapping links between entities to aid in the understanding of the structures and patterns contained within these links. If the objective is to discover the existence of particular links between nodes (as in discovering suspicious links in insurance claims data, or anti-money laundering or counter-terrorism data), then the summarizing methodologies are likely to be of only limited value compared to the linkage methodologies.

NetMap is also a network analysis tool, but one that differs from other network methods since it derives primarily from and applies to the field of "complex adaptive systems" or "complex networks" (e.g., Watts 1999; Barabasi 2002) and only secondarily from the field of "social network analysis." NetMap is based on a set of concepts that derive theoretical support from General Systems Theory (GST) and the field of cybernetics. General Systems Theory assumes that there are many systems that cover all sorts of matter-energy ranging from the smallest cells found in microbes to the universe as a whole. There are systems of systems which gives rise to the notion of systems hierarchies and levels comprising supra systems and sub systems, etc. GST also assumes various boundary conditions (permeability, transitivity and so on) that need to be taken into account when considering definitional aspects of systems. It follows from this that a system comprises components (or elements) which are inter-dependent with each other. NetMap adapted this to process individual items of data as "nodes" (or entities) along with instances of "links" (or relationships) between them, plus "attributes" of both. It uses these basic concepts to discover patterns and relations that would be otherwise difficult to find, and then to model them as a network or series of networks.[13] The concepts of NetMap are extremely simple – just nodes and links plus attributes on both. Hence, in principle, given any available data, any system and its interactivity can be described, and therefore modeled, as a series of nodes with attributes and links between them with attributes. And if it can be modeled interactively and visually as a network of data, then interventions and 'what if' situations can be examined in a reasonably holistic (yet drillable) way in order to solve problems that are difficult to solve any other way (e.g. statistics alone) and improve the system.

Unlike statistical methods (including traditional data mining) which assume that the data records are independent, and similar to social network analysis, NetMap assumes non-independence of records or observations, and in fact, is designed to build upon and exploit such non-independence. In summary, NetMap uses the connectivity or linkage between otherwise disparate data to discover irregularities through discovery enhanced by its unique visualization tools.

[13] A full discussion of the conceptual background and methodology of NetMap can be found in Galloway 2006.

Visualizing Relational Data. There are many methodological tools used to display relational data. We compare graphs produced by the three methods in this paper: NetMap, social network analysis (SNA) and our geometric representation model. Traditional SNA methods use several different display methods although most use "spring embedding" layout algorithms (Quinn & Breuer 1979; Eades 1984). These employ "coil spring" or "force directed" principles to direct the positioning of nodes. The notion is that all nodes are initially assumed to be repulsed from each other and dispersed in placement. Nodes that are linked to each other (directly or according to path lengths), however, are attracted and brought closer to each other in the layout display. The result is often the "overplotting" of nodes. When large volumes of linkage are trying to be understood, traditional SNA graphical methods are problematic (Mutton and Rodgers 2002). Layouts do not scale well or improve "sense making." Indeed, it has been recommended that "[T]he best results of spring embedding are obtained for sparse, tree-like graphs" (Leda, 2006).

NetMap overcomes problems associated with spring embedding. With conceptual roots in the field of complex systems and complex networks, NetMap is designed to handle very large volumes of relational data (is highly scalable) and is suited to linkage of varying density and high dimensionality. One reason is that it represents network data in the form of a circle. The circle may have distributed around it, either different "node types" or one "node type" grouped into categories. The former is primarily suited for NetMap's use as an NDM tool, whereas the latter is primarily used as a SNA tool – e.g. countries trading with each other grouped by "region", people interacting grouped by "market segments," or "business units" within an organization. This form of representation has advantages even for very small volumes of data, however, because of the "templated" sameness of structure (e.g.. regions are always located at approximately the same location across graphs, and colors for types of trade are consistent for a subset of the analyses).

The interactive and multidimensional nature of NetMap enables any links and any combinations of them to be selected and displayed so that one's intuition can be facilitated "on the fly" (including the application of coloring, dotted/dashed/solid links, directional links, or thickness of link according to any link attribute such as trade value). There are also numerous displays that can be used to discover relationships within data, including the use of spring embedding displays for small and sparse data sets. The circular displays are often the initial starting points for becoming familiar with the data and overall patterns. It is generally the best way to draw and display "many to many" relationships. In fact, there is no other logical way to represent "any to any" and "many to many" relationships. This is especially true when significant volumes and multiple types of linked data need to be understood.

Because the numbers of links that can occur between nodes explodes rapidly with the addition of just a few more nodes, the problem of visualizing linked data is very real. There have been many attempts to solve it, but it is clear that linear displays simply extrapolated in one direction with more links can quickly become overly complex. Instead of adding clarity they add confusion.

Most of us like to visualize relationships in terms of hierarchies. We have been taught to think that way: relationships structured in a nice orderly fashion. Most significant analytical problems and the information/data sets that refer to them, however, are not hierarchically structured. Hence, a non-hierarchical display methodology is required to properly represent the data, if detection of the underlying relational patterns and resolution of the problem is to occur.

Beyond them however, the user has available numerous algorithms and display options such as step linking, emergent groups, discrete networks, dynamic wizard manipulations. These are particularly useful to focus and localize the analysis and also serve as differentiators from other methodologies. The step link display allows the user to select a node and then “step out” any number of steps from that “origin” node. In general, stepping out a few steps is sufficient. One notable exception occurs when the user wants to see if there are any connections between “origin” node(s) and “destination” node(s) and, if so, who or what are the “intermediaries” serving to bring about the connectivity. Alternatively, a user may want to see if by adding additional node(s) or link(s) one can cause connectivity to be observed between otherwise disparate origin and destination nodes.

Another algorithmic and display option not found in other methodologies is emergent groups. This enables closely inter-connected entities to be grouped and displayed as localized structural subsets, in effect enabling vast quantities of linkage to be decomposed into lower order substructures. This capability is particularly useful for discovering “irregularities” in patterns without having to write a rule or set a threshold when one does not know ahead of time how to do that. It also is particularly useful in SNA contexts. We will use examples from the analysis of our trade data to illustrate three of the most common algorithmic and display methods: circle, emergent groups, and step linking.

Figure 1 shows patterns of trading relationships between countries and is intended to demonstrate how NetMap is used as an SNA tool to ‘make sense’ of explicit linkages. This graph is for total trade for 2001. The main circle in the middle of the graph represents relationships between countries and across all regions—inter-regional ties. This particular regional clustering is based on UN continents, but any grouping can be used (e.g., economic wealth, membership in trade groups, etc.). Countries are represented in the images with boxes and trade linkages are indicated by lines. Countries are color coded according to their geographical region. The thickness of the line indicates the relative value of the trade link. The directionality of the link is indicated by a gap in the line closest to the importer. A solid line with no gaps at either end indicates reciprocal trade flows. The dark color in the middle of the main circle results from the density of ties between countries. NetMap has several interactive features to discover both the nodes linked by this trade relationship, the amount involved, and whether this represents an export or import or two-directional tie. Although the nodes are not readable in this graph, NetMap allows for a zoomed image that highlights each component. The point of this graph is to obtain an overview of the structure of trade.

The interactive feature allows us to identify each region. The countries in the “orange” bloc at 11:00 are the Americas and include NAFTA countries and several Caribbean and Central but not South American countries. The green-colored wedge to the right is composed of Unknown destination/partner. Following in a clock-wise fashion, the red-colored bloc is composed of African countries; followed by a yellow bloc of South American countries; a blue-colored bloc of Asian and Middle Eastern countries; a green-colored bloc of Australia and various island countries and a dark blue-colored bloc of European countries.

The satellites outside of the main circle show relationships between countries within a region –intra-regional relationships. Generally, the density of these ties varies. In a study of telecommunications, the graph revealed dense intra- and inter-regional ties between wealthy "Northern" countries and almost no intra- and inter-regional ties for African countries.

NetMap Visualizer tools allow the user to limit the number of linkages shown by specifying trade linkages that are equivalent to or larger than a selected percentage of the value of total world trade. Figure 2 shows total trade at 0.3% threshold for 2001. This graph is instructive on several levels. Although grouped by UN continents, we note only the NAFTA countries remain from the Americas; only Brazil and Venezuela from South America; the leading economic powers in Asia and from Europe, the countries sharing the euro currency—grouped in most of these analyses as Euro-12 countries. The structure represents the core countries comprised of the economic leaders of North America, Europe and Asia. The figure is consistent with claims from world systems theory and trilateralism.

Figures 3 and 4 shows total trade at 0.3% threshold grouped by WTA regional categories for 2001. Figure 3 collapses the Euro currency countries in one unit while Figure 4 does not. The effect of combining the Euro12 countries results in 21 countries rather than 12 European region countries trading at this threshold. Combining them also reveals Russia, Denmark, Hungary, Norway, Sweden and Turkey to trade at this threshold while the Czech Rep, Poland, Switzerland and the UK remain in both analyses. All of the other groupings remain the same with a strong showing from both East and SE Asia. Saudi Arabia is the only ME country and there are no countries from Africa, the India subcontinent, or Oceania (Australia and NZ included). Mexico is also grouped with the 2 other Latin American countries, losing the impact of the effect of NAFTA evident from the 1980 graphs.

Figures 5 and 6 shows total trade at 0.3% threshold grouped by WTA regional categories for 1980. Figure 5 collapses the Euro currency countries in one unit while Figure 6 does not. Although generally it is instructive to start with the earlier years first, it was interesting to delete several countries from East (now only Japan and Taiwan trade at this threshold) and Southeast Asia (only Indonesia). It was also interesting to add 4 countries in Africa. Either direction, you see gains and losses in several regions with the two key North American nodes remaining constant—US and Canada and Europe remaining strong. When you combine the Euro12 countries, several effects are noticed. First, not all of the countries trade as strongly on their own although 7 of them remain constant; you lose Scandinavian countries and Russia/USSR. Switzerland and the UK remain in both configurations. Interestingly, you also lose Iraq. In both the 1980 and 2001 graphs, there are strong inter-regional ties between Europe, North America and East Asia, supporting arguments of a persistent triad core. The loss of Africa in the later period and the strengthening of regions dominated by strong free trade agreements suggests regionalization is a better explanation than globalization. Finally, note that in 1980, the U.S. has the widest array of trade linkages. Except for Southeast Asia, the U.S. is trading at high levels with every region of the world. Within North America the U.S. also trades with Canada. The thickest or greatest amount of trade occurs between the

U.S. and the Euro-12, U.S. and Japan, U.S. and Canada, and Euro-12 and the U.K. An example of a unidirectional trade flow in 1980 is seen in the satellite for Europe, and occurs between Switzerland and the U.K.: the gap near Switzerland shows that at this high level of trade, Switzerland is an importer but not an exporter.

Figures 7 and 8 shows total trade at 0.3% threshold grouped by WTA regional categories for 1990. Figure 7 collapses the Euro currency countries in one unit while Figure 8 does not. 1990 is the period of transition centered in the end of the Cold War and the dissolution of the Soviet Union. The first thing you notice is the increase in the number of countries in East and SE Asia trading at this level—the same countries trading at this level in 2001. Mexico continues to be the only Latin American country trading at this level. NAFTA and MERCOSUR come later so their influence is not observed until 2001. This is the only year where Australia trades at this level (and only with Japan). Saudi Arabia is the only ME country trading at this level. The graphs differ for Africa, the Baltics and Europe. The Euro12 graph shows the Former USSR and Libya (Africa) trading at this threshold but not in the graph without the Euro12. For Europe, the Euro12 graph is the same as for 1980 except Romania has been replaced by the Former Yugoslavia; for the graph without the Euro12, Sweden and Spain have been added. Spain joined the EU in 1985 and it appears to have had a positive effect on its economy.

Figures 9 (Euro12) and 10 (without Euro12) shows total trade at 0.3% threshold using the emergent group algorithm. Emergent groups are closely inter-connected entities identified and displayed as local sub-networks. This feature enables very large quantities of linkages to be decomposed into lower order substructures. This is particularly useful for network data mining when discovering "irregularities" in patterns without having to write a rule or set a threshold when one does not know ahead of time how to do that. It is also particularly useful in numerous SNA contexts. One application for example is in discovering "cells" and "hubs" within groups. All of the countries in the center circle trade more with each other than with any other country. The countries in the satellites outside the circle only trade at this threshold with the node contained in the circle. A quick comparison of the 1980 WTA regional and emergent groups with the Euro12 cluster makes inter-regional trade of the top traders clearer to see. For example, the US has very thick lines with Canada, Euro12, UK, and Japan but also strong trade with Mexico and Taiwan, located in a satellite outside of the circle, indicating they only trade at this threshold with the US. Interestingly also, South Africa is seen as trading with "Areas nes", a category of unknown destination, possibly representing overriding trade sanctions imposed at this time. Finally, also evident is that the same countries represented in the regional groups at this level are in this group but 9 of them trade at this level only with one other country. In Figure 10, only 10 nodes are part of the inner circle and the rest are peripheral. The US is clearly dominant in this image. There is also a clear triad—US, Euro-12, UK, Japan.

Figures 11 (Euro12) and 12 (without Euro12) shows total trade at 0.3% threshold using the emergent group algorithm. Figure 11 reveals Canada and Mexico as members of the internal group now with the only external tie to the US being Venezuela. This is assumed to be an affect of NAFTA, strengthening member countries in inter- and intra-regional trade. There is a clear Asian-North American-Euro triad; with only Saudi Arabia representative of any other part of the world. Figure 12 shows a clear domination of European regional trade by Euro12 countries which also have strong ties to the US and

Japan. The US is now a central node with Asian countries (Japan, Taiwan, Thailand, Singapore, Malaysia, South Korea, Hong Kong, China). This makes it look like the US dominates Asia which we did not see in the aggregated Euro12 graph for this period. This is a good example of the both the exploratory potential of NetMap and the value of using other methods to examine the same data. Our next method uses traditional social network methods and graphing techniques.

<u>Social Network Analysis</u>:

There are many ways to find similarity in relations among states using standard social network methods. Here we choose an approach that was first applied to international trade by Smith and White (1992). This analytical strategy draws from the substantive concerns of the world-system perspective, along with the methodological tradition of *Positional and Role Analysis* of Social Networks. As Wasserman and Faust (1994) note, "There are two key aspects to the positional and role analysis of social networks: identifying social positions as collections of actors who are similar in their ties with others, and modeling social roles as systems of ties between actors or between positions" (Wasserman and Faust 1994: 351). As will become clear later, this present analysis is largely confined to the first task—the identification of collections of actors who are similar in their ties with others—but the results make the other task—modeling systems of ties between positions—possible.

As discussed above, the world-systems perspective was an early tradition that held that a country's role and position in a hierarchically organized world economy, determined its subsequent developmental trajectories. Thus, in its early renditions that were closely coupled with dependency theory, the world-systems perspective held that the world could easily be classified into three role groups: Core, Semi-Periphery and Periphery. The roles these three groups play in the world economy were determined by their position in the international division of labor. According to Chase-Dunn, "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). Thus, core countries' production regimes are primarily capital intensive, while peripheral countries' regimes are primarily labor intensive or based on the export of raw materials. Conceptually, the core/periphery distinction is one of a continuum. Countries that have a relatively equal mix of core and peripheral production processes are labeled semi-peripheral and reside between core and periphery countries in the hierarchical structure. According to this classificatory scheme, it is highly unlikely that countries with little to no advanced industry can move up into core production processes because they lack the necessary levels of capital, infrastructure, workforce skills and technical expertise to do so. In addition, core countries maintain their unique position because they provide capital-intensive goods and technological innovations required by all regions of the world economy. They also have the largest markets in the world and tend to export and import large volumes of commodities to and from *many* countries located throughout the entire world economy. The role of non-core countries, on the other hand, involves specializing in exports of raw materials and, increasingly, intermediate processed goods to higher zones in the hierarchy. Consequently, these countries will tend to have fewer trading partners, most of which are located at higher zones in the hierarchy (Mahutga, 2006). In summary, studies informed by the world-systems perspective attempt to measure the extent to which the structure of international trade is organized hierarchically, and more importantly to uncover the subgroups that correspond to Core, Semi-Periphery and Periphery.

Our network analysis therefore follows this tradition by 1) applying a regular equivalence algorithm that measures the similarity of each actors trade profile to each other actors trade profile; 2) determining which groups of actors are relatively equivalent to each other vis-à-vis everyone else by a) performing a hierarchical clustering routine to the matrix of regular equivalencies and b) scaling the matrix of regular equivalence into a two dimensional Euclidian space; then 3) superimposing steps 2a and 2b above onto each other and 4) using a somewhat subjective method of agreement between 2a and 2b to produce a set of relatively equivalent positions in the structure of international trade.

Regular Equivalence. The first step in this analysis calculates the degree of regular equivalence for each pair of countries with the following algorithm.[14] The regular equivalence (M_{ij}^{t+1}) between countries *i* and *j* at iteration t+1 is:

1) $$M_{ij}^{t+1} = \frac{\sum_{k=1}^{g} \max_{m=1}^{g} \sum_{r=1}^{R} M_{km}^{t} \left({}_{ijr}M_{kmr}^{t} + {}_{jir}M_{kmr}^{t} \right)}{\sum_{k=1}^{g} \max_{m}^{*} \sum_{r=1}^{R} \left({}_{ijr}Max_{kmr} + {}_{jir}Max_{kmr} \right)}$$

where the denominator is the maximum possible value of the matches between the profiles of *ik* and *jm* that would occur if all of the ties between *i* and its alters (*k*) were perfectly matched to the ties between *j* and its alters (*m*), and all of *k* and *m* were regularly equivalent. The numerator determines the *best matching* of the ties between *j* and *m* for *i's* ties to *k* weighted by the regular equivalence of *k* and *m* from the previous iteration (Wasserman and Faust, 1994). Thus, the algorithm determines the best possible matching of ties between *i* and *j* weighted by the equivalence of their alters, and divides that value by the maximum possible value of the numerator. It is important to remember that the equivalence of each pair of actors is revised after each iteration $(t+1)$. We have specified three iterations, with the third serving as the measure of regular equivalence for each pair of countries. It is highly unlikely that any two nations would be exactly equivalent, so applying a regular equivalence algorithm to three matrices including the sum of all the traded commodities for countries that report their trade in 1980, 1990 and 2001 produces an equivalence matrix in which the *ij* cell equals the regular equivalence between *i* and *j* that measures between maximally dissimilar (0) and regularly equivalent (1).

Hierarchical Clustering. In this analysis, we use the matrix of regular equivalencies as input for a single link hierarchical clustering routine for each year. Since the matrix of regular equivalencies gives a measure of equivalence between each pair of actors, the hierarchical clustering routine is well suited to finding "cut points" that minimize the between group variance in regular equivalence (or maximize the within group similarity). Hierarchical clustering starts by putting each actor in an NxN matrix into its own cluster so that the similarity between clusters equals the similarity between each actor. The procedure then finds the most similar pair of actors and merges them into

[14] The original trade matrices were transformed with the base 10 logarithm to reduce skew. For an overview of the method, see Borgatti 1994; and Borgatti and Everett, 1992, 1999.

one cluster. The third step computes similarities between the new cluster and each of the other actors. The second and third steps are carried out until all actors have been merged into a single cluster of size N (Borgatti, 1994). In principle, an analyst could start out with some α criterion whereby actors *i* and *j* would be considered regularly equivalent if $RE_{ij} \geq \alpha$. However, there is no a-priori theory that favors one level of alpha over another, and large real world data sets are rarely broken down into discrete homogenous groups at any single threshold level. Thus, we use the hierarchical clustering results in conjunction with correspondence analysis to determine the boundaries of each equivalence group.

Correspondence Analysis. Correspondence Analysis is one of a family of techniques that draw on a common computational foundation: the Singular Value Decomposition (SVD). Included in this family of techniques are Principle Components Analysis, Factor Analysis and Optimal Scaling, to name a few. While the SVD is common to all these approaches, it is the pre-processing that is done to the data that differentiates between them. In the context of our present analysis, correspondence analysis is simply a singular value decomposition preformed on a matrix **H** in which the cells of the original matrix have been transformed so that the row / column marginals are approximately 1, with the following equation:

2) $$h_{ij} = f_{ij} / \sqrt{f_i . f_j .},$$

where h_{ij} is the transformed value in **H**, f_{ij} is the original value in the ij^{th} cell of the regular equivalence matrix, $f_i.$ is the row marginal, and $f_j.$ is the column marginal.
Rather than discuss the computational aspects of a singular value decomposition, we instead focus on the conceptual issues involved in performing and interpreting a correspondence analysis. At a basic conceptual level, correspondence analysis represents the basic structure in a set of data by decomposing the transformed matrix into its three component parts: a matrix **U** that summarizes the information in the rows; a matrix **V** that summarizes the information in the columns, and a diagonal matrix of singular values **d** that weights each **UV** vector by its importance to the overall structure. The matrix **d** of singular values is always arranged from largest to smallest, where large singular values explain much variation, and small singular values explain less (Weller and Romney, 1990). The third step in a classic correspondence analysis rescales the information in **U** and **V** to obtain "optimal," or "canonical" scores by multiplying both **U** and **V** by the square root of the ratio of the total marginals to the row / column marginals, respectively:

(3) $$X_i = U_i \sqrt{f../fi.} \text{ and } Y_i = V_j \sqrt{f../f.j}$$

The final step incorporates the singular value "weights" so that each dimension of **X** and **Y** is multiplied by the square root of its respective singular value. In sum, correspondence analysis begins by generating **H**, which is a transformation of the original matrix (in this case, a matrix of regular equivalencies) so that the marginals (or expected values) are removed. It then performs a singular value decomposition on **H** to produce three matrices, **UV** and **d**. As a third step, correspondence analysis rescales **U** and **H** with equation 3 to produce the **X** and **Y** matrices. Finally, correspondence weights each **X** and **Y** dimension by their associated singular values to produce a multidimensional representation of the similarity between actors (in this case country regular equivalencies) in which each dimension is successively "less important" to the overall structure.[15] These results can be easily visualized by plotting successive dimensions of either **X** or **Y**, or **X** and **Y**. Thus, correspondence analysis allows us to represent actors in a multi-dimensional Euclidian space by assigning coordinates (weighted dimensions of **X** and **Y**) to actors that place them close to those with whom they are similar and far from those with whom they are dissimilar (Weller and Romney, 1990). Since our matrix of regular equivalencies is symmetric, e.g., **X** = **Y,** we can simply plot one or the other. Finally, one can evaluate the "fit" between single or multiple dimensions with the following equation:

$$(4) \qquad 100 \times \frac{\lambda_m^2}{\sum_{m=1}^{M} \lambda_m^2},$$

where *M* is Singular Value 1, 2, 3, …*M*. Interpreting the results from correspondence analysis depends on the amount of variation explained by each singular value/dimension and the observed spatial pattern of objects in the Euclidian space. Thus, one can have a relatively simple structure (few significant dimensions) or a complex one (many significant dimensions).

Superimposing the hierarchical clustering results onto the Correspondence Analysis results. The final steps brings the results of the two complementary procedures—hierarchical clustering and correspondence analysis—together to derive a set of positions to describe the structure. This third step can be broken down into three stages. In the first stage, we examine the hierarchical clustering results in the form of a dendrogram to give a first approximation of the groups from that analysis. The dendrogram (see Figure 13 for a sample excerpt derived from the 1990 analysis) reads from left to right, with the brackets on the left indicating a merger at the higher levels of regular equivalence, and then merges at descending levels of regular equivalence as you read to the right. The groupings are usually fairly obvious in this step, but sometimes it may make substantive sense to either split or merge a group at a higher/lower level of equivalence than the rest of the actors. After visually inspecting the dendrogram for regularly equivalent groupings, the next stage compares those results with the correspondence analysis solution by sorting each country by their first dimensional correspondence analysis coordinate, and then by the blocks we derive from visually inspecting the dendrogram. This generally gives a pretty consistent interpretation except that there may be individual countries at the boundaries of the clustering groups that, when viewed in conjunction with the first dimension of the correspondence analysis results, can be moved to another group to produce a consistent grouping. Thus, the final stage of this procedure seeks consistency between the correspondence analysis results and the hierarchical clustering results. Because the hierarchical clustering procedure can be derived in several ways and therefore vary, while the CA results are always consistent, we rely on the block the CA analysis produces.

Social Network Graphing. Adjacency matrices represent information about the data in numerical form which can be difficult to interpret. An adjacency matrix by itself

[15] The reader should note that the first dimension of U and V, and the first singular value in d are considered trivial since they will always equal 1, by construction (see equation 2 above).

will not yield insights into patterns, particularly when you have large data sets. Graphs can extract the information and display it in a way that can allow you to visualize the global structure of the data and identify patterns (Michailidis and de Leeuw 2001:435; see also Michailidis and de Leeuw 1996; McGrath and Blythe, 2004; McGrath, Blythe and Krackhardt, 2002; and McGrath, Krackhardt and Blythe 2002). They can represent relationships between sets of objects and model complex systems. They have mathematical properties that have been well examined. There is also a large body of research on graph drawing which addresses the algorithms that can optimize the researcher's desired properties.

Graphs contain only the qualitative information, so vertices can be located anywhere in the plane. The vertices of the graphs are represented as points in R space and the edges as lines connecting the points (Michailidis and de Leeuw 2001:439). Graphs use different algorithms designed for different purposes. These include satisfying aesthetic rules such as symmetry, minimization of edge crossings, distribution of vertices and uniformity of edge lengths. The goal is to draw the graph in a way that shows "important and invariant aspects of the data…whose structure and properties" can be examined analytically (Michailidis and de Leeuw 2001:436).

Social Network Analysis and Results. The graphs for Figures 14-15, 18-19, and 22-23 use a spring embedding algorithm in a program called Netdraw[16] which results in the world system zones being represented by concentric circles with the core in the center and the semi-periphery 1 and 2 and peripheries 1-3 layers around it. The graphs for Figures 16-17, 20-21 and 24-25 display the results from the correspondence analysis of regular equivalence. The X axis represents the first dimension and the Y axis represents the second dimension. The resulting structure places the "core" at the top right hand of the graph with semi-peripheries 1 (blue nodes) and 2 (orange nodes) directly underneath and to the left. The 3 categories of peripheral countries are farther to the left. Periphery 3 nodes are located the farthest from the core, as you might assume. Thus, the first dimension of the correspondence analysis of regular equivalence can be thought of as a measure of "coreness," where closeness to the upper right most point corresponds to the level of "coreness." Notably, there is no change in the structure over time. Tables 1a-b display the coordinates for each country for the three years. These can be compared to see if individual countries move in position over time.

Figure 14 shows trade ties for all countries for 1980, colored by world system zones. The density of the ties makes the relationships between individual nodes difficult to see (unlike the NetMap images which show ties between countries more clearly and unlike the graphs produced by the exponential distance model which show clusters of nodes based on overall similarity but does not show links). The algorithm places the core countries (represented by pink nodes) in the center of the graph with the semi-peripheral countries nearby (semi-periphery 1 represented by blue nodes and semi-periphery 2 represented by orange nodes). The three levels of peripheral countries are located in roughly concentric circles around this group. Figure 15 is the same graph showing only ties between countries that trade at 0.3% of total trade. Here the graph more closely approximates the results of the NetMap image for this subset of the data. Table 1a shows the coordinates for the first dimensional measure of "coreness" from the CA of RE for 1980 and 1990 along with the group they were placed in by the hierarchical clustering

[16] Netdraw is one of the graphing programs integrated with Ucinet; see Borgatti, Everett, Freeman 2002.

analysis. The country names have been colored to represent the world system zones to match the graph. The full names of the countries are also represented for easier identification if the abbreviations for a country are not known. Figure 16 uses the coordinates from the 1980 network analysis as attributes and creates a graph that "layers" countries according to the zone or bloc they represent. Figure 17 is the same graph showing only countries that trade at .3% of total trade.

Figures 18 through 21 show the same order of graphs for 1990. There is evidence of some transition of countries primarily in the semi-peripheries which are also evident in Table 2a where a difference in the hierarchical clustering (HC) groups can be seen. The same overall hierarchy persists. Figures 22 through 25 show the same order of graphs for 2001. Again we see the same overall hierarchy but note that there are more countries in the "core" and more movement overall between groups (see Table 1b for additional information). This is worth exploring more in our commodity chain studies of specific commodities. It can provide insights into what factors enable some countries to improve their position in the global economic hierarchy.

Exponential Distance Model:

Introduction. A trade table is a square matrix F with frequencies. Rows and columns of the table correspond with a number of countries, the same countries for rows as for columns. Cell f_{ij} of the table indicates how much country *i* exports to country *j,* or, equivalently, how much country *j* imports from country *i*. The diagonal of the table usually consists of missing data, because countries do not import from or export to themselves. Thus, using terminology from Haberman (1974) and Bishop et al. (1975), the diagonal of the table has structural zeroes.

Model. We suppose the f_{ij} are realizations of independent Poisson variables $\underline{f}_{ij}$, with $E(\underline{f}_{ij}) = \lambda_{ij}$. It is well known that by conditioning on the row marginals this model also covers the product multinomial model, in which rows are independent multinomials. The negative log likelihood for the Poisson model is

$$(1) \qquad \Delta = \sum\sum \{\lambda_{ij} - f_{ij} \log \lambda_{ij} \mid i \neq j\}$$

The assumption of independent Poisson cells is made for convenience, for the same reasons the assumption of normality is made in continuous multivariate analysis. Alternatively, one can simply think of (1) as a natural way to measure the distance between the observed frequencies f_{ij} and the expected frequencies λ_{ij}.

Base Models. The two key specifications that we shall elaborate on in this paper are the quasi-independence model, which says that

$$(2a) \qquad \lambda_{ij} = \alpha_i \beta_j \qquad \forall i \neq j$$

and the quasi-symmetry model, which says

$$(2b) \quad \lambda_{ij} = \alpha_i \beta_j \eta_{ij} \qquad \forall i \neq j$$

where $\eta_{ij} = \eta_{ji}$. The η_{ij} are called *similarities*. Clearly quasi-independence is the special case of quasi-symmetry in which all similarities are equal. In the quasi-independence model, each country has an *export effect* α_i and an *import effect* β_j, and the amount of trade between countries is just determined by these export and import values. Export and import values will be influenced by the population of the country, but also by its wealth and trade balance. Clearly China has an exporting economy, and the US has an importing one.

In the quasi-symmetry model the trade is determined by both export and import values and the similarity. The similarity is an unobserved parameter, but it is expected to be related to geographic distance, and also political and economic affiliations.
Both the quasi-symmetric and the quasi-independence model are base models, in the sense that we do not expect them to be even approximately true but we can use them as baselines with which to compare our hopefully more realistic models.

Geometric Models. We can restrict the quasi-symmetry models further by requiring that the similarities are inversely related to distances on an unknown map. In particular we assume the *quadratic Euclidean model*

(3a) $$\eta_{ij} = \exp\{-\sum_{s=1}^{p}(x_{is}-x_{js})^2\}$$

The problem is now to recover the map, along with the import and export values of the countries. Alternatively, our software can also fit the *simple Euclidean model*

(3b) $$\eta_{ij} = \exp\{-\sqrt{\sum_{s=1}^{p}(x_{is}-x_{js})^2}\}$$

but for various reasons we will initially concentrate on the quadratic case in this paper. Geometric models of the form (3a) or (3b) have been proposed many times, and in many different contexts, in econometrics, psychometrics, and sociometrics.

Correspondence Analysis Approximation. Let us look more closely at the quadratic Euclidean model. By expanding the squared distance we have

$$\eta_{ij} = \exp\left\{-\sum_{s=1}^{p} x_{is}^2\right\}\exp\left\{-\sum_{s=1}^{p} x_{js}^2\right\}\exp\left\{+2\sum_{s=1}^{p} x_{is}x_{js}\right\}$$

If we define

$$\overline{\alpha}_i = \alpha_i \exp\left\{-\sum_{s=1}^{p} x_{is}^2\right\},$$

$$\overline{\beta}_j = \beta_j \exp\left\{-\sum_{s=1}^{p} x_{js}^2\right\},$$

and $\overline{x}_{is} = \sqrt{2}x_{is}$ then for the squared Euclidean model

$$\lambda_{ij} = \mu\alpha_i\beta_j \exp\left\{-\sum_{s=1}^{p}\left(x_{is} - x_{js}\right)^2\right\} = \mu\bar{\alpha}_i\bar{\beta}_j \exp\left\{\sum_{s=1}^{p}\bar{x}_{is}\bar{x}_{js}\right\}$$

which says that the squared Euclidean model is equivalent to the *inner product model*. Instead of fitting exponents of negative squared distances, we could also fit exponents of inner products, and obtain basically the same results (with an exactly equal goodness-of-fit). For the next step in the approximation, observe that if z is small, then exp(z) ≈1 + z. Thus if the inner products are small, then

$$\lambda_{ij} \approx \mu\bar{\alpha}_i\bar{\beta}_j\left\{1 + \sum_{s=1}^{p}\bar{x}_{is}\bar{x}_{js}\right\}$$

and this is the model used in the symmetric version of Correspondence Analysis (if one insists on interpreting Correspondence Analysis as a model fitting technique). In ordinary Correspondence Analysis one computes separate maps for rows and columns, which means that the squared Euclidean distance model is approximated by a Correspondence Analysis model with row and column scores equal. These approximations are also discussed in detail by Goodman (1991).

Fitting. Fitting the model means maximizing the Poisson likelihood. We have constructed convergent iterative algorithms, with corresponding computer implementations in the R programming language, based on the majorization principle (for example, De Leeuw, 1994). We shall not give the details of the algorithm here, but it amounts to solving a sequence of multidimensional scaling problems on transformed data.[17]

EDM Results and Analysis. The graphs for this analysis are more representative of actual distance between countries while the graphs for the CA of RE represent the Euclidean distance between the RE of each country. Figure 26 shows the results for the exponential distance model for 1980. There is a clear cluster of triad/core countries in the lower right hand corner of the table. (Table 2a provides the coordinates from the analysis along with the full country name.) Countries that were identified as members of semi-peripheries 1 and 2 are located in closest proximity followed by the peripheries 1-3. There are clear groups of small island and African countries located in P2 and P3. P1 has several countries from Central America, the Caribbean, and a few from Africa. Figure 27 shows the results for the exponential distance model for 1990. There is a clear cluster of triad/core countries in the upper left hand corner (placement vis a vis 1980 does not matter; just clusters and distance from one another). What differs in this graph is less distinction between the clusters. Countries from the two semi-peripheries have moved closer, notably Asian countries. We also notice a density of peripheral countries in the upper left hand corner. Clearly this is a time of transition which is seen in Figure 28, the graph for 2001. The shape (horseshoe) of this graph is very similar to that of 1980 (only upside down). There is a clear cluster of triad/core countries (and more of them) in the top right hand corner and a very dense group of semi-peripheral countries nearby. We see many more Asian countries (in addition to Japan, China, Hong Kong, Malaysia,

[17] Code is available from the authors.

Singapore, South Korea, and Taiwan), NAFTA members Canada and Mexico; and many former Eastern European countries. These are the clear global winners; the sub-Saharan African countries in the dense cluster on the left hand side of the graph are the clear global economic losers.

Tables 2a-c display the coordinates for 1980, 1990, and 2001 respectively. Tables 3 (1980), 4 (1990) and 5 (2001) compare the results from the first dimension of the correspondence analysis (with country names colored according to the world system zone it represents) with the first dimension of this exponential distance model. We correlated these two dimensions and found about a 0.8 correlation for all three years indicating high similarity in the clusters found in these two methods. Next to each column of coordinates, we include the block number from the hierarchical clustering analysis ("HC groups") to show the world system zone to which the country belongs. (See Appendix A for the information on the color and number corresponding with each zone.). Finally, we added a column to compare the results of the NetMap clusters. Because this method was very different than the other two, we just include a "1" if the country was found to be in the top 0.3% of trade and a "0" otherwise. The clusters are strikingly similar across all three methods.

Summary and Further Research:

The focus of this paper was to explore the changing structure of global trade during a period of significant political transformation, e.g., the end of the Cold War and the dissolution of the Soviet Union resulting in not only many newly independent states but changing economic, military and political alliances. Although the dataset for this particular analysis was relatively small, the combined dataset we are collecting for the globalization project is massive. A dataset of this type and scope—e.g., relational data across economic, political and social dimensions—requires a good database program and a relational data mining program that is highly scalable, multidimensional, and with a "templated" display methodology (for consistencies in layout) to explore and discover relations of interest. Visualization is also central to this project as a good graph can provide insights and convey relations in a way many words can not. NetMap, our network based data mining program, is an important tool and first step in data management and data mining and provides a unique way to depict relations that is both highly readable and provocative, stimulating deeper research and analysis.

Our second method, social network analysis, offers essential tools for discovering similarity in relations and uncovering the structure inherent in a number of relationships. There are also a variety of graphing programs with an array of algorithms that are excellent for illustrating the structure among relationships. Frequently, however, these generate "overplotted" displays that are less readable for very large datasets. Finally, our third method, the geometric representation model, offers a measure that captures similarity of trading relationships between countries while accounting for factors such as geographical distance that can be assumed to be a factor in any trade relations.

All three of our methods found essentially the same clusters of countries, and each suggest a structure that modifies the traditional conception of world systems zones. (See Tables 4-6 for a comparison of clusters from all three methods by year.) The overall pattern of global trade suggests a combination of several predicted patterns. The dominant pattern is clearly one of trilateralism: US-led North America with NAFTA central to increased growth; EU-led Europe; and Japan-led East Asia with China having remarkable growth in the post Cold War time period and following its membership into the WTO. Related to this is a Northernization with the Triad members clearly part of the global North. There is clear evidence of Regionalization evidenced by the growth in major trade agreements, particularly NAFTA and the EU. It remains to be seen what regional trade agreements will dominate in Asia and which countries will benefit the most. Trade agreements among African countries appear to have more of a local than a global affect. Rugman's study of MNEs also underlines the dominance of the triad and suggests regionalization or internationalization is a better description of the global economy.

Finally, there is the continuing persistence of world system zones, which are historically path dependent. Although we found it instructive to classify countries forming clusters or blocs of similarity according to the traditional world systems zones, we do note divergences. For example, in 2001, Mexico is included as a "core" country. Although Mexico can not be considered a core country in general, it now trades at high levels with traditional core countries. Presumably this is because Mexico is a member of a central (core) trade agreement—NAFTA. This membership has influenced its overall levels of trade and its position in the structure of global trade. Can free trade agreements account for the improved status of some countries of the semi-periphery and periphery? Why did several Latin American countries move up the global economic hierarchy while sub-Saharan African countries became even more peripheral? Is it because trade agreements do not include wealthy countries of the global North? These are questions with important policy consequences. They relate to important issues of inequality which in turn has been attached to arguments of human rights—e.g., whether there should be an economic justice component. Predictably, there is a split between the wealthy countries of the "global North" and the poor countries of the "global South."

This paper was meant as a first step and as such, to generate as many questions as it answered. Important next steps include dynamic or longitudinal models which look at change in both the structure of world trade and the position of individual countries within this structure. It is also important to look at the reasons for these changes by considering other factors such as country attributes (levels of wealth, political regime type, levels of freedom, etc.) and country memberships (important trade, security and political agreements and participation in organizations focused on these areas). We are currently working on two other methods which address these: three-way models and models incorporating external information.

Three-way Models: Suppose we have trade tables between countries for different years. Of course these tables could be fitted separately using the models we have explained so far, or they could be pooled and fitted in a single analysis. Neither of the two approaches adds anything to what we have discussed above. There is an intermediate approach, which is more interesting. We can use a model such as

$$\eta_{ijk} = \exp\left\{-\sum_{s=1}^{p} w_{ks}\left(x_{is} - x_{js}\right)^2\right\}$$

in which the import and export maps are the same for all years, except for the fact that the dimensions of the map have different weights in different years. The same type of equation applies to one-point models, to simple Euclidean models, and to Correspondence Analysis approximations. We will usually also allow for the import and export effects to vary over years, which means that we will get the expected values

$$\lambda_{ijk} = \alpha_{ik}\beta_{jk} \exp\left\{-\sum_{s=1}^{p} w_{ks}\left(x_{is} - x_{js}\right)^2\right\}.$$

Otherwise the techniques for fitting and the geometrical representations are pretty much the same, with the modification that in this case we have to solve a sequence of three-way multidimensional scaling problems. Computer code for this generalization is already available.

Incorporating External Information. In the WTO datasets there is much more information than just the trade between countries. Additional variables describing countries can be incorporated in at least three different ways. First, we can use a multivariate regression to predict the coordinates from the exponential distance analysis from the external variables. This shows how the geometric solution can be interpreted in terms of the additional information we have. Second, we can regress each of the additional variables on the coordinates of the geometric solution.[18] This allows us to draw the additional variables as directions in the map defined by the geometric models. The projections of the countries on these directions approximately reproduce the external variables. This is a standard way to deal with additional information in multidimensional scaling (Gower and Hand, 1996). And third, and perhaps most interestingly, we can incorporate the external information in the exponential distance analysis directly. This means that we require that the coordinates X of the map satisfy a constraint of the form X=ZB, where Z is the matrix with the external information and where B are regression coefficients which now must be fitted by the iterative algorithm. We do not allow for arbitrary maps any more, we require the map coordinates to be defined as a linear combination of the economic and political variables describing the countries.

Exploring the results of these two models will provide a more complete understanding of the mechanisms underlying the structure of world trade and the factors that give rise to the biggest changes. They will also provide important insights into how much regionalization explains changes in the global economy and how much of a role free trade agreements play. Certainly NAFTA, EU and ASEAN have been central to both individual country, regional and global position and wealth. How important are other ties—political, security for example—and other variables such as cultural similarity to the apparent durability of the global economic hierarchy?

Conclusion and Future Research:

The study addressed three key questions: 1) What methods can we use to assess the impact of changes associated with economic globalization processes? 2) Do patterns of international trade conform to a core / periphery structure through time?; and 3) What

[18] See Krempel and Plumper, 2003.

other (non-economic) factors impact the structure of world trade? In addition to the results from the comparison of methodologies above, we found other important generalizations and paths for future exploration. First, we will continue to expand on the model we are developing to incorporate geographical, political and economic variables which question 3 addresses. An important variable we will examine further is the effect of regional trade agreements (RTAs). There is some evidence that RTAs of core members appear to have had a positive impact on the trade growth of member countries individually and relative to overall trade. Interestingly, several Latin American countries have experienced upward mobility—some are notably members of MERCOSUR. This is in marked contrast to the further marginalization or peripheralization of African countries who are currently the global economic losers. We intend to explore the relationship between RTAs, inequality and development and their impact on globalization.

In addition, future research will explore the structure of trade of individual commodities, examining both the role of countries in global commodity chains and how this impacts the international division of labor. This study can potentially provide insights into a question posed by Michael Mann: can the pressures of comparative advantage reduce Northern domination of the global economy? (Held and McGrew 2000:140). The 1999 United Nations Development Project (UNDP) Report notes that stronger governance is needed in order for more countries to benefit from globalization (Held and McGrew 2000:341). Kick and Davis (2001) note that political and security ties among states help explain economic ties. Our study suggests the entrenchment of the global economic hierarchy is based on the strength of "interlocking" ties among the wealthy countries and their trading partners. We believe exploring the structure of multiple transactions over time can provide us with insights into the role and position of multiple entities (states and non-state actors), how these are impacted by globalization processes, and what mechanisms are involved in large scale structural changes. This information can be invaluable in exploring policy development in all dimensions of social life. We also believe that evaluating global governance structures is an important component to understanding the structure of the global economy, particularly as the US currently dominates the WTO and IMF, central world economic institutions.

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