**Testing World Systems Theory in 2000s**

*An Application of Block Modeling Approach*

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## Introduction

Human society is a complex web of interactions that spurs multitude effects on the individual participants as well as the network as a whole. In sociology, there are two prevalent views of a analyzing a network: interactionism and structuralism. While interactionism focuses on individual characterization, thought process and individual level relationships, structuralism focuses on the structures on the institutional level that guide individual roles. Interactionist viewpoint in network analysis theory is exemplified in works of Mark Granovetter on strength of ties and Ivan Chase who discussed interaction hierarchy through chicken pecking order. Notable thinkers that emphasized on the role of social structure on human behavior, include Karl Marx, who emphasized on two level class structure and Georg Simmel who extended the alter orientation on family.

In world economic theory, some, such as, development theorists or modernization theorists, look at nations as individual units of analysis while others, such as, world systems theorists argue that structural position of nations is important in globalization and macroeconomic studies. In this paper, I will review the background of world systems theory and a popular network analysis method, block-model approach, that is used to systematically determine the structural position of a nation. I will then replicate the approach used by Ronald Breiger to determine the positions of 1972 OECD nations in his work, “*Structures of Economic Interdependence Among Nations*”, to analyze how has the structural position of major economically contributing nations has evolved in the recent times. Considering, that new major economies, such as, China, have emerged onto the world scene, I hypothesize to see a shift in which countries form the core nations, yet the core-periphery structure of world systems still exists.

## Literature Review

World system theory, largely credited to Immanuel Wallerstein, is a line of thinking that encourages economic or social analysis from a total world wealth and event standpoint rather than using nations or isolated events for such analysis. Specifically, regarding economic development of nations, much like dependency theory, world system theory disagrees with the, “linear notion that the historical growth of Western societies represents the pathway of development for the contemporary Third World” (Nemeth and Smith 518). Instead, the inherent structure of capitalist global economy would maintain the inequality and status quo.

In the 1950s and 60s, Latin American scholars questioned the tenets of modernization theory that promoted the spread of rational thinking, capitalist ideology and democratic institutions to build the foundation for the economic advancement of all nations. They argued that countries remained underdeveloped due to the structure of international relations and not an inherent cultural or economic characteristic. While the dependence theorists emphasized on two-way relations between wealthy, advanced, imperial nations and less developed, colonized nations, the world system theorists extended this two-partition thinking into a grid of interdependence that can be divided into unequal exchange relations of necessary bulk commodities. Wallerstein theorizes that countries can be divided into three positions: “*core* states appropriate the surplus of the world economy as a whole and in particular of those states located in the *periphery*, which produce lower-ranking (labor intensive) goods, while states located in the *semiperiphery* are ‘both exploited and exploiters” (Breiger 354).

While core-semiperiphery-periphery division of the world gained acceptance, there was a lack of unified consensus on which countries held this position. In 1979 paper by Snyder and Kick, focused on a multinetwork analyses to find the structural positions of countries. They combine the world system theory with block model analysis to evaluate the structural positions that nations hold in world trade. Snyder and Kick, critique that the world systems theory, prior to their work, lacked operational rigor for classifying nation’s position in the system or even structural necessity of three-tiered model in a capitalist world economy (the dominant world system for decades, according to Wallerstein). Additionally, previous regression analyses required a choice between focusing on poor countries to test the “effect of economic or cultural imperialism on economic growth” or include all available data for all nations leading to dubious arguments like Rubinson’s claim that, “a nation’s exports and imports (as a percentage of the GDP) puts the state and its economic actors in a position of less power and control in the world economy” (Snyder and Kick 1101). These are refuted in the economic standings of countries like USA and Japan. Finally, they urge that previously utilized indicators such as investment dependence or trade concentration do not completely represent the nation’s position as they “do not fully specify the institutional locus of transnational flow” (Snyder and Kick 1102). To address this, Snyder and Kick, conduct a multinetwork, block-model analysis on data from 118 countries for four important networks: trade flows, military interventions, diplomatic exchanges, and conjoint treaty memberships. Their analysis strongly supported the world systems theory.

Snyder and Kick utilized the block-model approach of Breiger, White, and Boorman. Consequently, Ronald Breiger built on their work of block model analysis of world system theory, by using different international trade networks to determine a nation’s structural position. Breiger proposed that, “a block-model approach to international trade assigns states to positions according to the structural similarity of nations’ imports and exports to all other states, across various types of economic exchange, rather than on the basis of definitional aggregation” (Breiger 357). Breiger’s main objective was also to operationalize procedures to identify core, semi-peripheral, peripheral nations based only on trade networks and determine if the core-periphery structures allowed competing centers. Additionally, he intended to explore “the distinctive elements of core-periphery structure in contrast to other ideal type structures that might characterize international exchange” and determine if different exchange networks presented the same results (Breiger 355). Since, Beiger’s approach and results from “*Structures on Economic Interdependence Among Nations”* forms the basis of this paper, the following section of this paper his method in detail.

Following Breiger’s approach of using relational interaction of nations through international trade, Nemeth and Smith, also focus on international commodity exchanges in their paper, “*International Trade and World System Structure”*. The authors expand on Breiger’s work by using the same UN Comtrade data but include all nations with a population of over a million (86 countries in total) and do not arbitrarily pick the commodities. Instead, they use a principal component analysis on all commodities and reduce to five categories of commodity groups. Using CONCOR block-model technique, Nemeth and Smith also uncover the core countries in accordance to world systems theory. The paper ends with recommend future work on longitudinal data to test the pattern of trade in different periods but attest that the empirically method is valid for understanding world system structure. Nonetheless, they conclude that empirical analysis is a tool to understand modern world, but it should be used with in-depth comparative study.

Scholarly work refining the world systems theory, both qualitative and empirically, is extensive. However, here the focus was on key works that used the network analysis method of block-modelling to uncover the structural position of nations in world systems.

## Methodological Foundation

In this paper, the method from Breiger’s *Structures of Economic Interdependance Among Nations* will be replicated. He conducts a block model analysis of the import and export of 24 nations (OECD nations of 1972 and Israel) for selected commodities. In his study, Breiger formed exchange network matrix for agricultural products, raw materials, manufactured goods and energy resources. The focus of the study is to find groups of nations that are structurally like each other and “examine the possibly distinctive patterns that these blocks induce on the original network data” (Breiger 357).

Breiger creates a 24 by 24 matrix of countries import and export for each of the trade networks. He binarizes this matrix, by only considering the highest fifth of the interior cell values and then rearranges and partitions the rows and columns using block-model method. Robust block model algorithms for structural equivalence is a contribution by Harrison White, Scott Boorman and Ronald Breiger through their paper, *Social Structure from Multiple Networks. I. Blockmodels of Roles and Positions.* From this analysis, a distinct core-periphery pattern emerges that bears resemblance to the 118-country analysis of Snyder and Kick. However, he argues that world system theorist would not accept this empirical evaluation based on binarized trade data of one commodity as countries have unequal exchanges in import and export and that the results imply that the “world is bound together by a few core states” (Breiger 364).

To address this concern, Breiger uses Schwartz’s technique to net out unequal exchange. For the network data, “row and column means were subtracted from each matrix, leaving residuals from an additive, two-way analysis of variance model” (Breiger 365). Positive values indicated statistical interactions, while negative values represented the opposite. This method was applied to a single correlation matrix created by multiple networks: agricultural products, raw materials, manufactured goods. The block model algorithm used to cluster countries is, CONCOR (Convergence of Iterated Correlations), “a divisive hierarchical clustering procedure that continuously splits actors into successively smaller groups” (Nemeth and Smith 532). The eigen structure of the resulting matrix was examined and plotted to reveal geographical clustered nations with insight of historical events. Here Breiger, does urge to conduct a time series analysis to see how the positions differ in light of world economic events, such as, formal entry of UK into European Common Market. Breiger examines the correlations between the four matrices to establish that each of the trade matrices are quite different from each other. Therefore, to find any additional asymmetries, it is important to run a four block CONCOR partition to each of the networks. The correlation matrices are adjusted as previously described.

The study concludes that the core-periphery structure identified by Snyder and Kick holds but “adjusting for the total import and export levels of each country, … [reveals] the existence of multiple competing core” (Breiger 375). In the network diagrams (from Dr. Padgett’s notes) shown below, the pattern of competing core can be seen. USA, UK and Germany form the core while countries like Japan, Sweden and France form connections with additional countries but interesting do not overlap in trade between each.

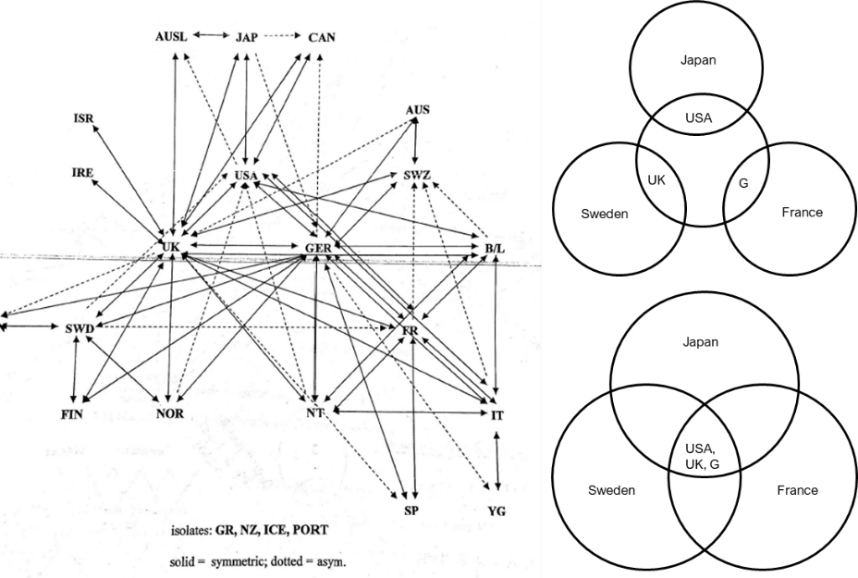
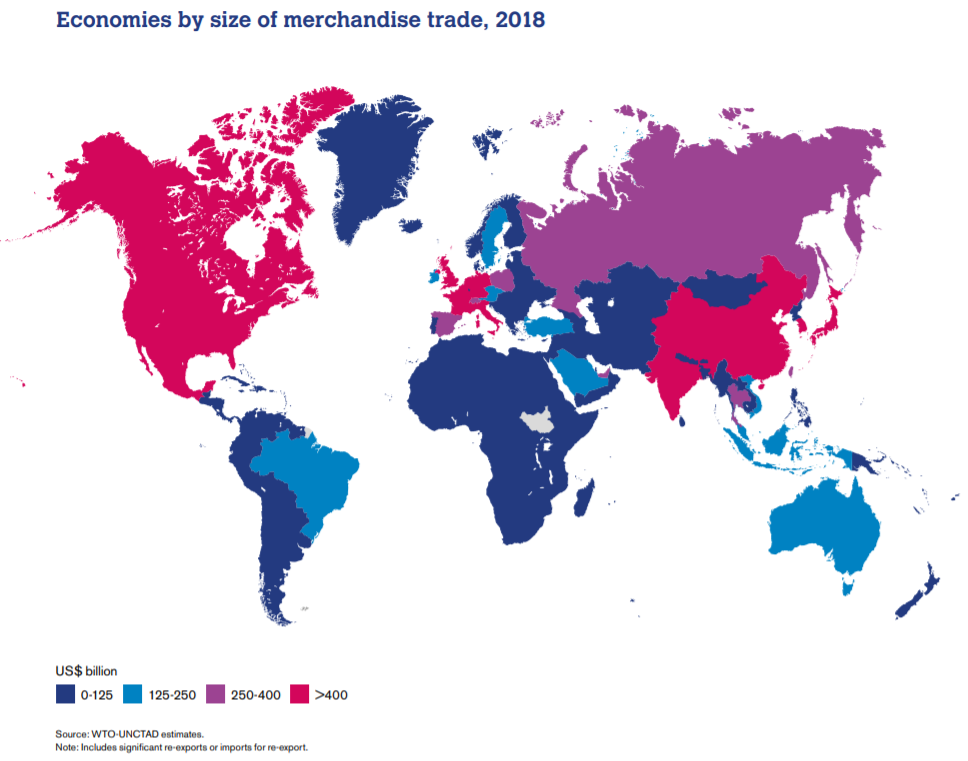


Figure 1 Network Diagram Created by Dr.Padget to Represent Breiger's 1972 Study

## Data

This study will use data collected and maintained by Organization for Economic Co-operation and Development (OECD), an organization that “work[s] on establishing international norms and finding evidence-based solutions to a range of social, economic and environmental challenges” (OECD) They have a large database of international trade statistics that has been collected for more than 60 years. Beiger chose to limit his study to 24 OECD nations of 1972 and Israel, since most of the world trade was accounted by them. However, that is no longer the case. The OECD has expanded to include 13 additional countries and non-OECD countries like India, China and Brazil, participate in world trade at a scale that cannot be ignored. According to world trade statistics, the merchandise trade was valued at US$ 19.67 trillion in 2018 and China was the leading merchandise trader (World Trade Statistics). The map shown below highlights the participation of countries in the merchandise trade. In 2018, “developing economies had a 44% share in world merchandise trade” (World Trade Statistics 14). In contrast, when Breiger conducted his study for 1972, the highly industrialized OECD nations, accounted “for over 70 percent of the world totals in 1972” (Breiger 360)



For this study, import-export trade data is collected from UN Comtrade database for the same commodity codes that Breiger used, 0, 2, 3, 6 (whose description can be found in the table below), for the years, 1972, 2007, 2008, 2013 and 2018.

Table 1 SITC Code Description for Data Collected

|  |  |
| --- | --- |
| **Commodity SITC Section Code** | **Description** |
| 0 | Food and live animals |
| 2 | Crude materials, inedible, except fuels |
| 3 | Mineral fuels, lubricants and related materials |
| 6 | Manufactured goods classified chiefly by material |

To determine the world structure in recent times, the latest data available, year 2018, will be used. However, “world systems analysis is directed to studies of social change in which the system itself is open to dynamic alterations”, therefore, a temporal analysis is done to evaluate, “the stability or fluidity of structure” (Nemeth and Smith 556). The year 2008 gives a picture of the world ten years prior. However, given that the year 2008 marked a major global financial crisis, to account for any situational differences, years 2007 and 2013 are considered to determine the structure of world in the recent times. For the year 1972, only the original countries from Breiger’s study are considered to replicate the results that Breiger found to benchmark the analysis process and account for any discrepancy in methodology.

Method

The same steps derived from Ronald Breiger’s approach to world system analysis is applied to each of the five years of datasets. Before applying the block model analysis, a rigorous data extraction and preparation is conducted. From the UN Comtrade database, the import-export data for each of the countries in consideration, in each of the years, is individually downloaded. Then, for each year in consideration, the data is cleaned and combined into one dataframe in Python’s Jupyter notebook. The combined dataframe is then cleaned to retain the commodity exchange with only the countries in consideration. That is, only the countries in OECD and India, China, Brazil (OECD and Israel for 1972) are retained for creating the matrix of reporter and partner nation. Additionally, any data for export, re-export and re-import are removed. Nemeth and Smith point out, referring to works of Duran and Linnemann, that, “only import data are used because, as a result of number of factors, reports on imports and exports do not always match perfectly and there is reason to believe that import figures are more accurate” (Nemeth and Smith 526). This discrepancy is observed in the data extracted in this study and since, Breiger’s method to address this is not clear, this study utilizes the import-data-only approach of Nemeth and Smith. Finally, all the country names are standardized.

Using Pandas Groupby command and filtering by commodity code in Python, the cleaned data is converted into a 39 by 39 (24 by 24 for 1972) matrix for each of the four international exchange networks. Additionally, since Breiger considers “only the highest fifth of interior cell values” in the first step in analysis, matrices that code 1 for the top fifth value and 0 for rest are also created. The data for each of the trade matrices is thus prepared and saved in csv format for block model analysis.

The block model analysis is conducted in a software specialized for network analysis – UCINET. The csv files are loaded into matrix editor and converted to UCINET native files and analyzed using UCINET’s CONCOR block model analysis. For all the years in consideration, three types of analysis is conducted: determine the correlation among the four trade networks; conduct block model analysis on each of the binarized trade network; and conduct multinetwork analysis on combined trade networks.

For single matrix analysis, a standard CONCOR block model with 3 part split is applied to each of the binarized trade networks to generate a block model partition and density matrix. For the multinetwork analysis, first, the rows for all four trade exchange matrices are joined and a correlation matrix is created for the combined network. The CONCOR block model analysis is run on this correlation matrix. Additionally, just as Breiger had adjusted for different intensities of trade using the method proposed by Schwartz, a matrix normalization is conducted on the rows and columns of the joined matrix using mean. A block model analysis is then also conducted on the correlation matrix of the normalized matrix.

Results

## Correlation among Trade Matrices



Figure 2 Comparison of Correlations among Trade Matrices for all Years

## 1972

### Part 1: Density Matrix for Binarized Trade Networks (*See Appendix for Block Models*)



Figure 3 Density Matrix with Positive Values Highlighted (1972)

### Part 2: Multinetwork Analysis (Non-Normalized and Normalized)

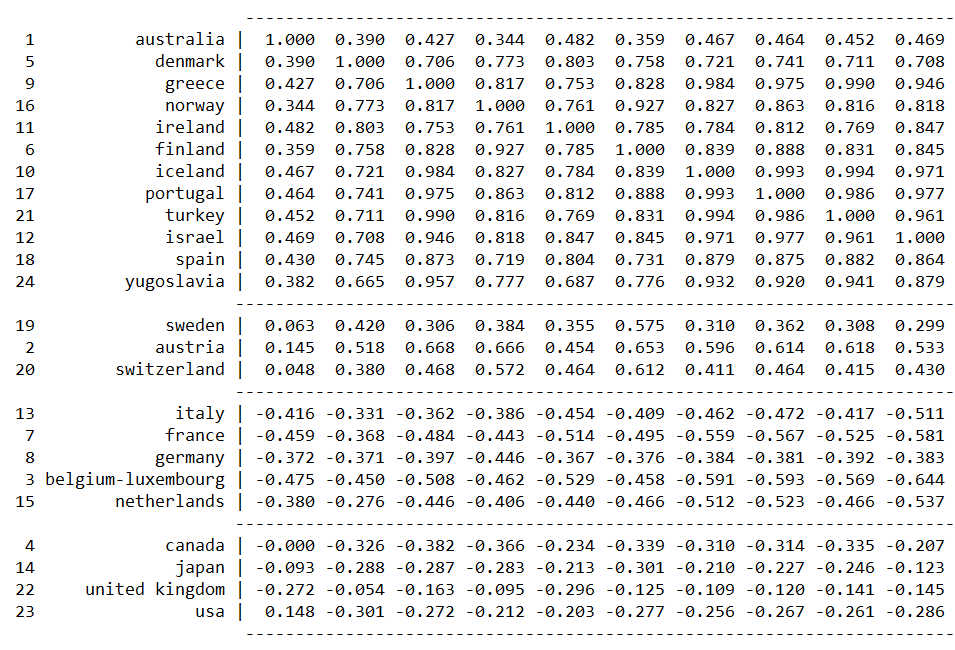
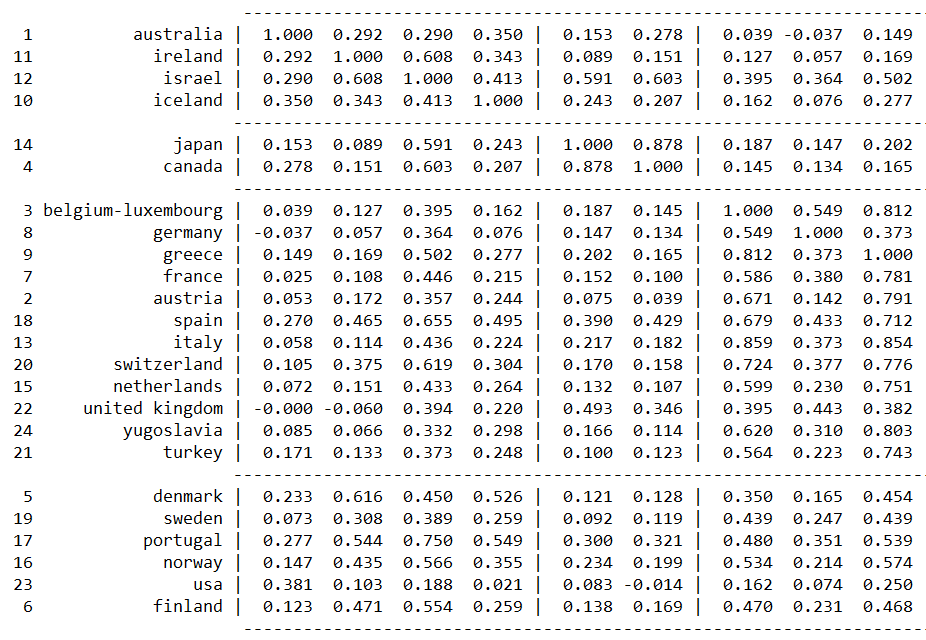


Figure 4 Part of CONCOR Blockmodel for Multinetworks (non-normalized on left and normalized on right)

## 2018

### Part 1: Density Matrix for Binarized Trade Networks (*See Appendix for Block Models*)



Figure 5 Density Matrix with Positive Values Highlighted (2018)

### Part 2: Multinetwork Analysis (Non-Normalized and Normalized)

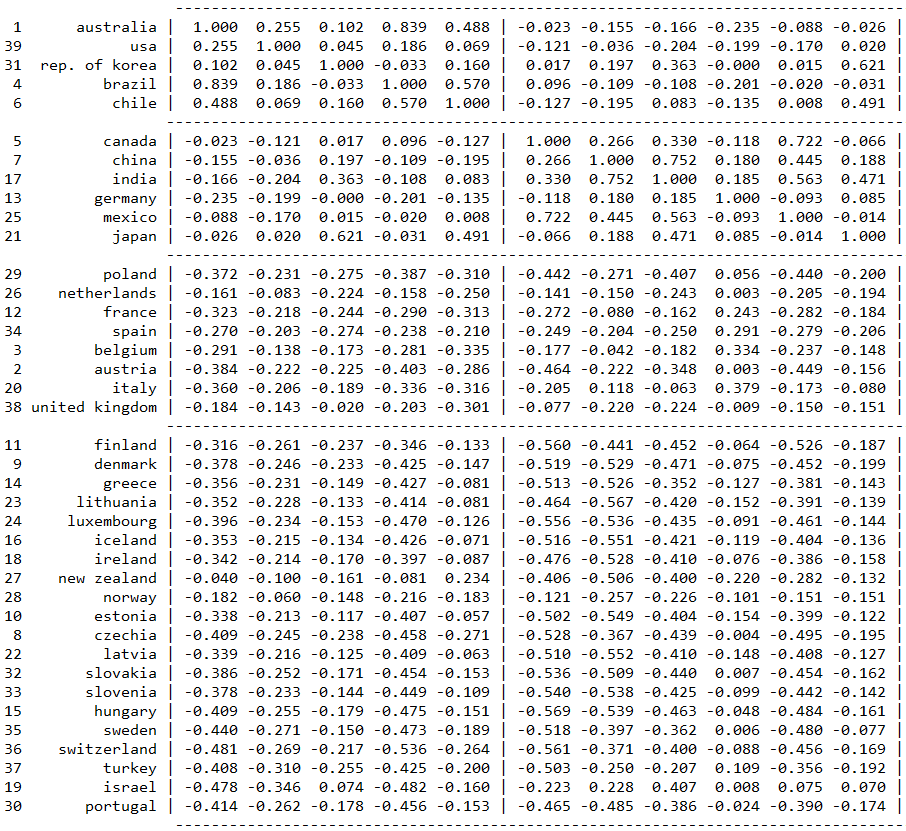
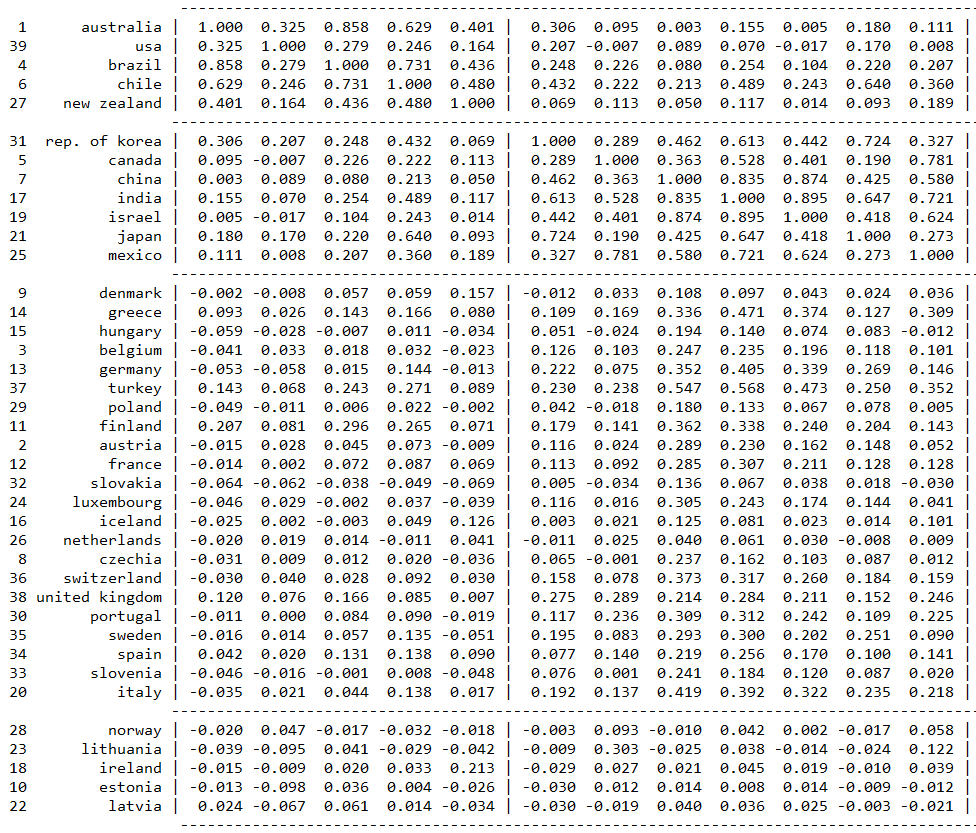


Figure 6 Part of CONCOR Blockmodel for Multinetworks (non-normalized on left and normalized on right)

## 2008

### Part 1: Density Matrix for Binarized Trade Networks (*See Appendix for Block Models*)



Figure 7 Density Matrix with Positive Values Highlighted (2008)

### Part 2: Multinetwork Analysis (Non-Normalized and Normalized)

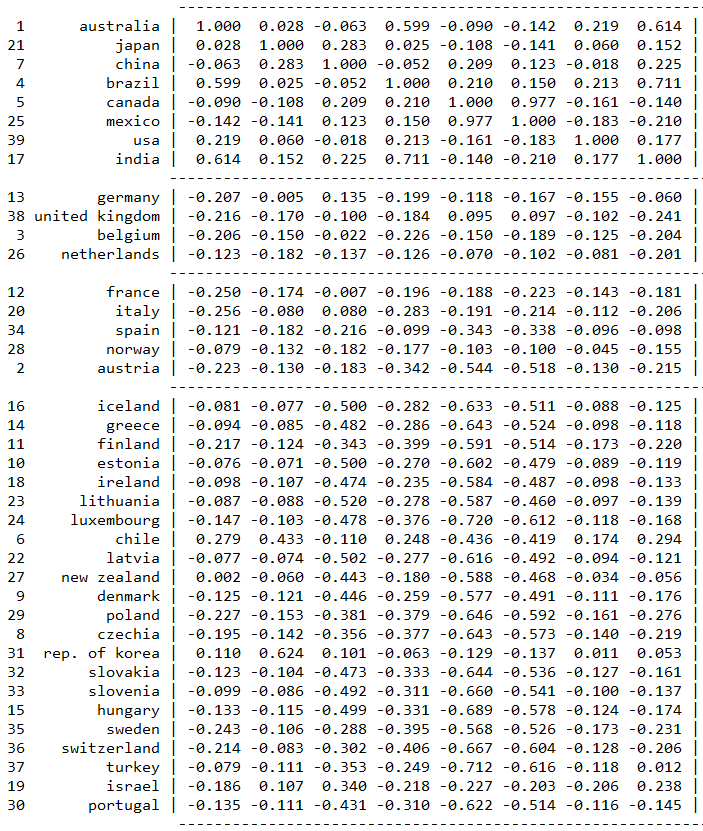
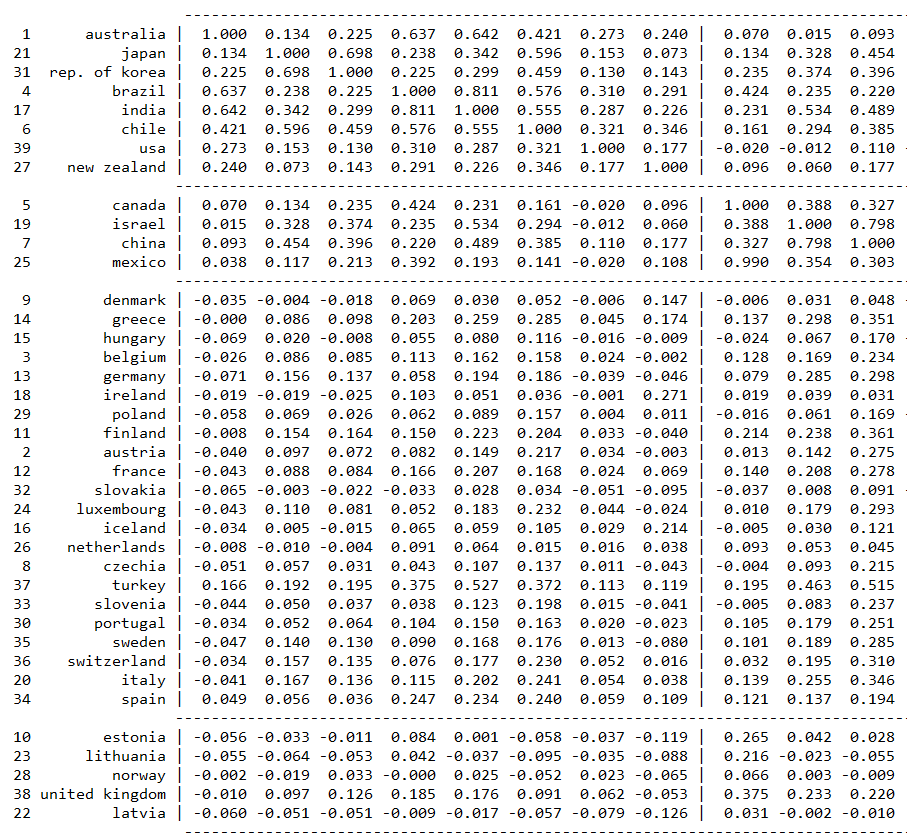


Figure 8 Part of CONCOR Blockmodel for Multinetworks (non-normalized on left and normalized on right)

## 2007

### Part 1: Density Matrix for Binarized Trade Networks (*See Appendix for Block Models*)



Figure 9 Density Matrix with Positive Values Highlighted (2007)

### Part 2: Multinetwork Analysis (Non-Normalized and Normalized)

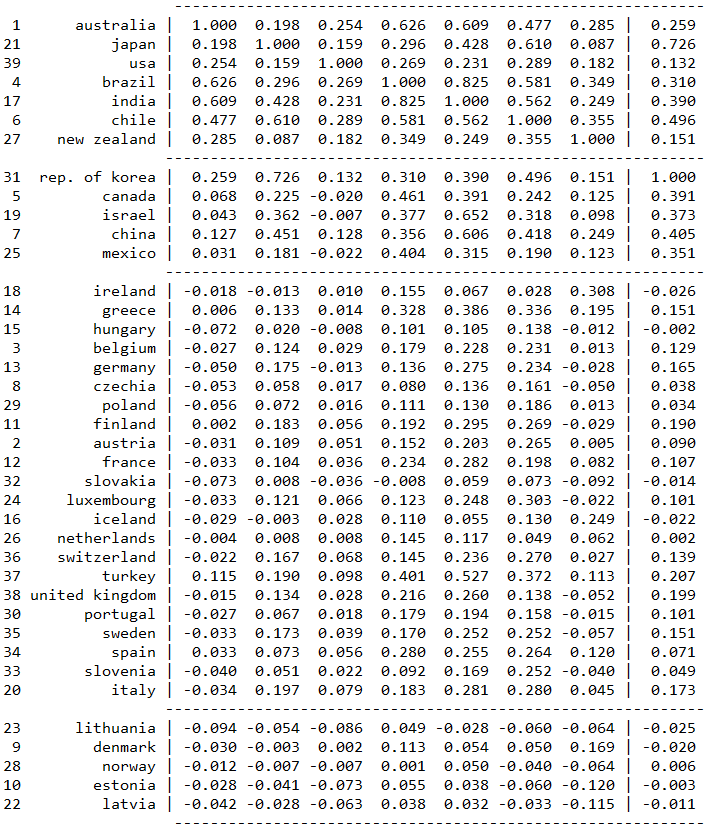
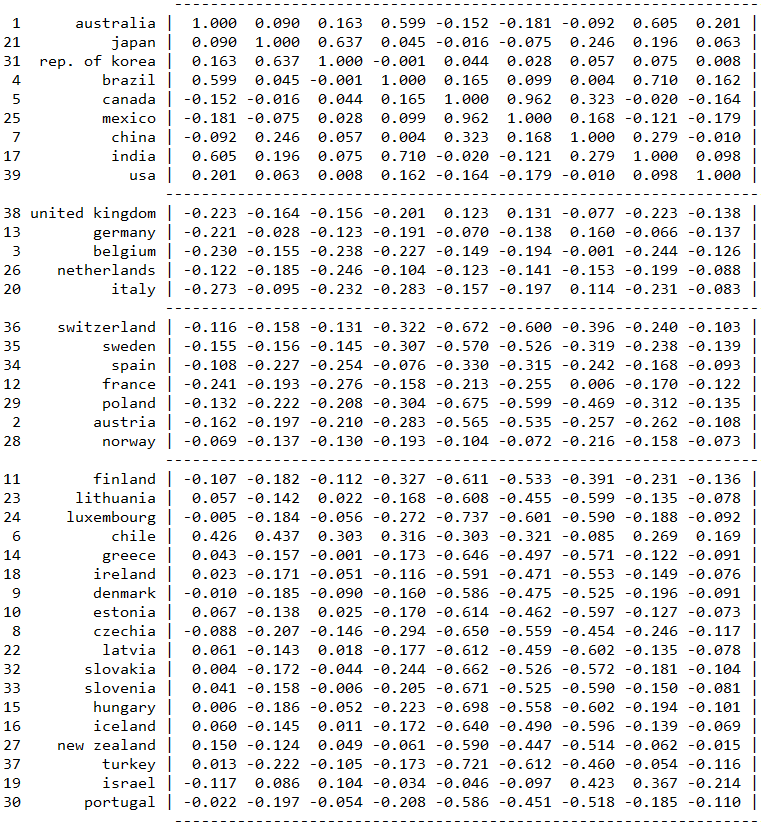
 

Figure 10 Part of CONCOR Blockmodel for Multinetworks (non-normalized on left and normalized on right)

## 2013

### Part 1: Density Matrix for Binarized Trade Networks (*See Appendix for Block Models*)



Figure 11 Density Matrix with Positive Values Highlighted (2013)

### Part 2: Multinetwork Analysis (Non-Normalized and Normalized)

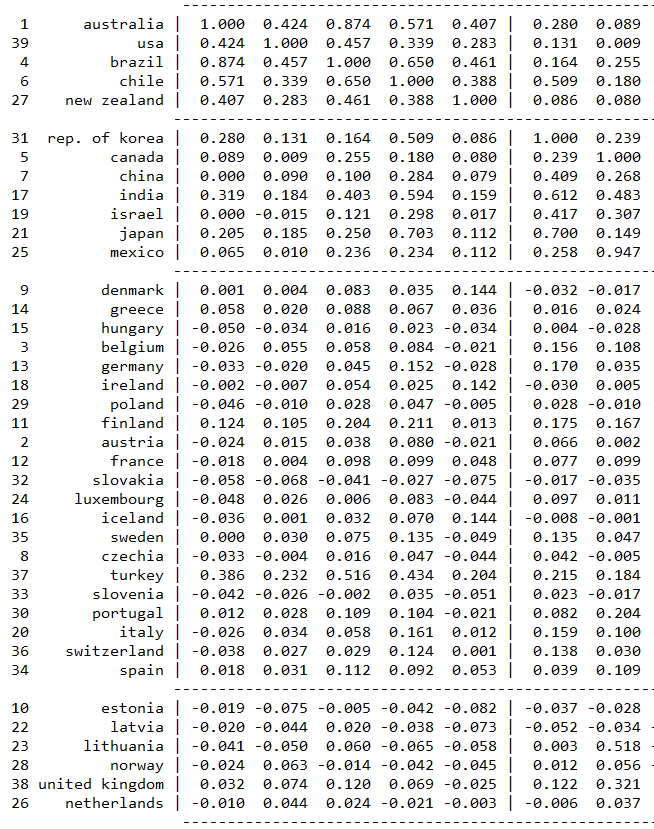
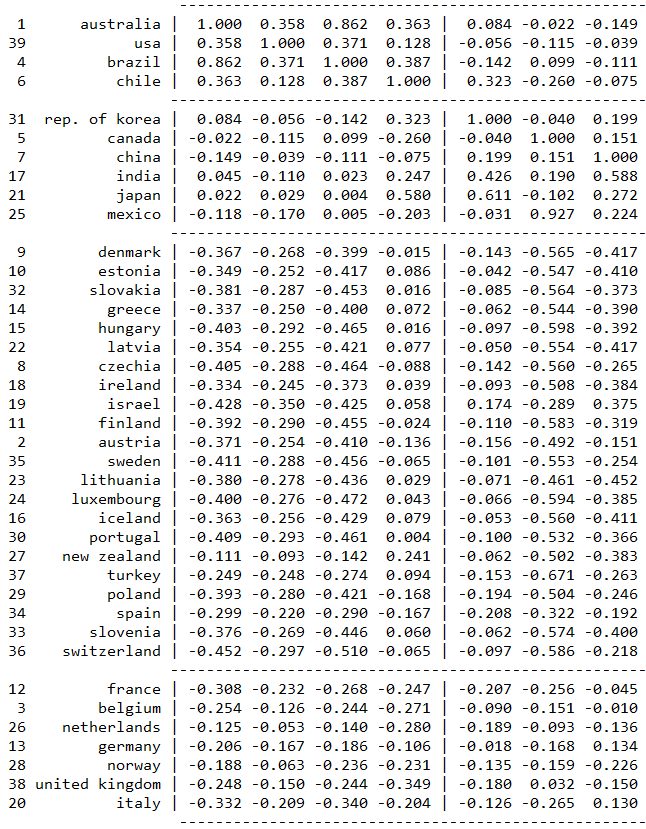
 

Figure 12 Part of CONCOR Blockmodel for Multinetworks (non-normalized on left and normalized on right)

## Discussion

The results of this study are represented in two main ways: a block model partition and density matrix (found in the results section and appendix). The block model partition helps determine which countries are subset together based on the equivalence in their trading pattern. While the density matrix is a quick way to visualize how the partitions relate to each other. A density matrix “is a matrix that has positions rather than individual actors as its rows and columns, and the values in the matrix are the proportion of “choices” that are present from the actors in the row position to the actors in the column position” (Faust and Wasserman 13). With these results, it is possible to evaluate if the countries still form the core-periphery pattern and which countries form the core.

When the results of the benchmark study of 1972 data are compared with Breiger’s results (included in the appendix), it is evident the results are not identical. For instance, the normalized block model from the combined networks in this study groups UK with USA, Canada and Japan while Breiger’s study groups UK with Australia. The differences in subsets of partition can be observed in Figure 4 and Figure 34. This pattern is evident in other results obtained for binarized trade networks as well as density matrix: the nations are partitioned in a similar manner but not the same.

The reasons for these differences could be the choice of data or an unintentional difference in methodology from Breiger’s original work. For instance, in this study, the network of trade exchanges is created using import data to address discrepancies in values but Breiger might have used another approach that is not explicitly stated in his paper, leading to differences in outcome. Additionally, this study utilizes UCINET’s generation of correlation matrix and normalization, that could be different from the steps employed by Breiger, leading to discrepancies in calculation.

Although the resulting nations are not identical from Breiger’s work and this study, the methodology applied in this benchmark analysis is deemed credible because there are limited number of countries that are partitioned differently and the density matrix for manufactured goods (Figure 3), follows a similar pattern to the mean value trade within and between blocks in Breiger’s analysis (Figure 33). As seen in Figure 13, the block model image of binarized manufacturing network in 1972, the nations in core have extensive trade among themselves compared to the ones on the outside. The missing piece of information from this image is the distinction that emerges from including the values that are exports only. Nonetheless, given that the benchmark analysis indicates an existence of core-periphery pattern in density matrices and produces similar nations in core, the methodology and data is used to explore the recent data.

The results in 2018

## Future Work

By looking at the

Look at intellectual transfers and control of information and financial markets

“Unequal exchange initially created and continuously maintains the structural division

Add link to github

## Conclusion

Through meticulous review and application of Ronald Breiger’s approach in identifying positions of OECD nations in Network analysis in sociology requires strong theoretical reasoning and methodological implications.

## References

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“World Trade Statistical Review 2019.” World Trade Statistical Review, 2019, doi:10.30875/7195c6e1-en.

## Appendix

Table 2 Complete List of Countries in Consideration

|  |  |  |
| --- | --- | --- |
| **INCLUDED BY BREIGER** | **COUNTRY** | **YEAR OF ACCESSION** |
| \* | **AUSTRIA** | 1961 |
| \* | **BELGIUM** | 1961 |
| \* | **CANADA** | 1961 |
| \* | **DENMARK** | 1961 |
| \* | **FRANCE** | 1961 |
| \* | **GERMANY** | 1961 |
| \* | **GREECE** | 1961 |
| \* | **ICELAND** | 1961 |
| \* | **IRELAND** | 1961 |
| \* | **LUXEMBOURG** | 1961 |
| \* | **NETHERLANDS** | 1961 |
| \* | **NORWAY** | 1961 |
| \* | **PORTUGAL** | 1961 |
| \* | **SPAIN** | 1961 |
| \* | **SWEDEN** | 1961 |
| \* | **SWITZERLAND** | 1961 |
| \* | **TURKEY** | 1961 |
| \* | **UNITED KINGDOM** | 1961 |
| \* | **UNITED STATES** | 1961 |
| \* | **ITALY** | 1962 |
| \* | **JAPAN** | 1964 |
| \* | **FINLAND** | 1969 |
| \* | **AUSTRALIA** | 1971 |
|  | NEW ZEALAND | 1973 |
|  | MEXICO | 1994 |
|  | CZECHIA | 1995 |
|  | HUNGARY | 1996 |
|  | KOREA | 1996 |
|  | POLAND | 1996 |
|  | SLOVAKIA | 2000 |
|  | CHILE | 2010 |
|  | ESTONIA | 2010 |
| \* | ISRAEL | 2010 |
|  | SLOVENIA | 2010 |
|  | LATVIA | 2016 |
|  | LITHUANIA | 2018 |
|  | BRAZIL | Not OECD |
|  | CHINA | Not OECD |
|  | INDIA | Not OECD |

## 1972: Binarized for each trade networks

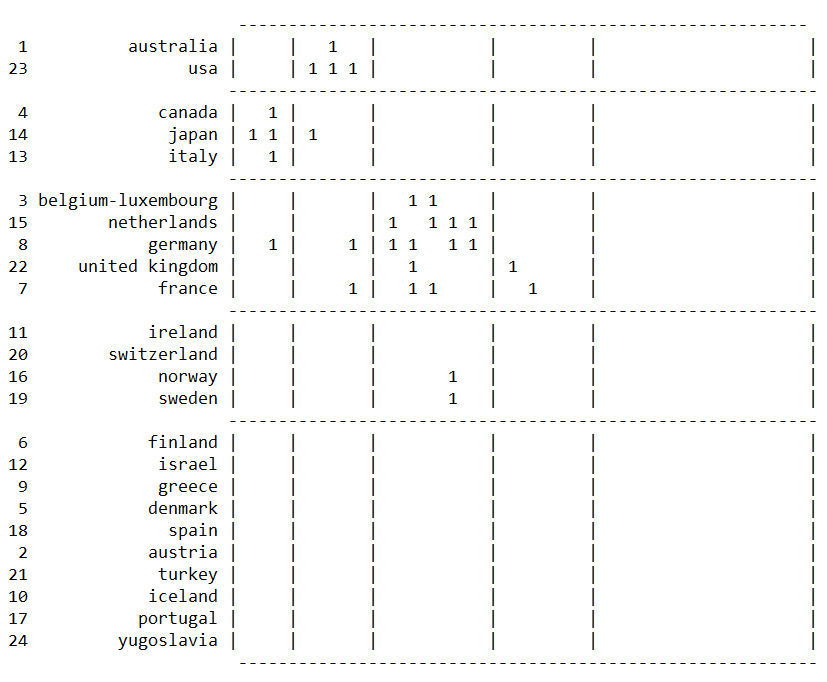


Figure 13 CONCOR Block Model for Manufactured Goods - 1972

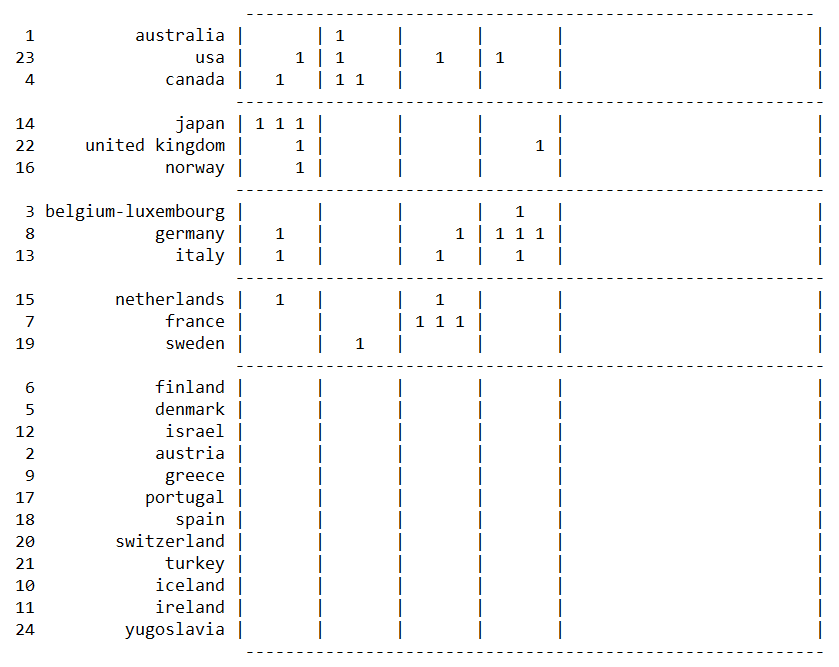


Figure 14 CONCOR Block Model for Raw Materials - 1972

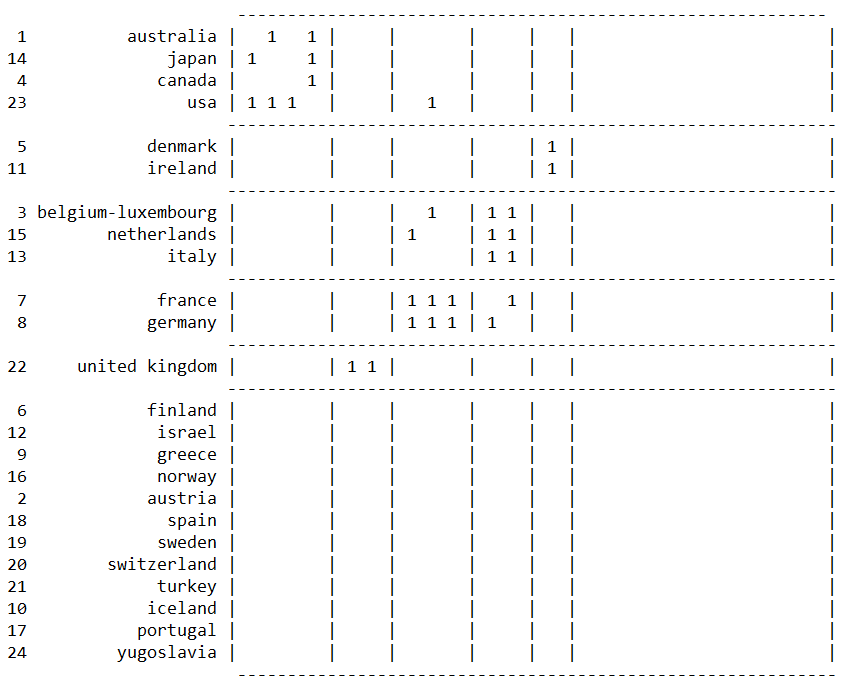


Figure 15 CONCOR Block Model for Agriculture Products – 1972

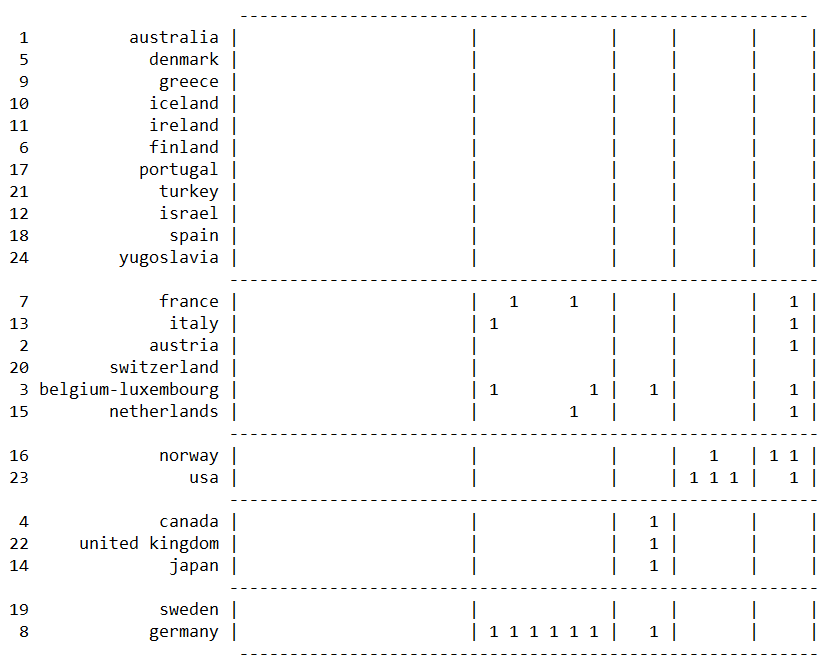


Figure 16 CONCOR Block Model for Energy Products – 1972

## 2018: Binarized for each trade networks

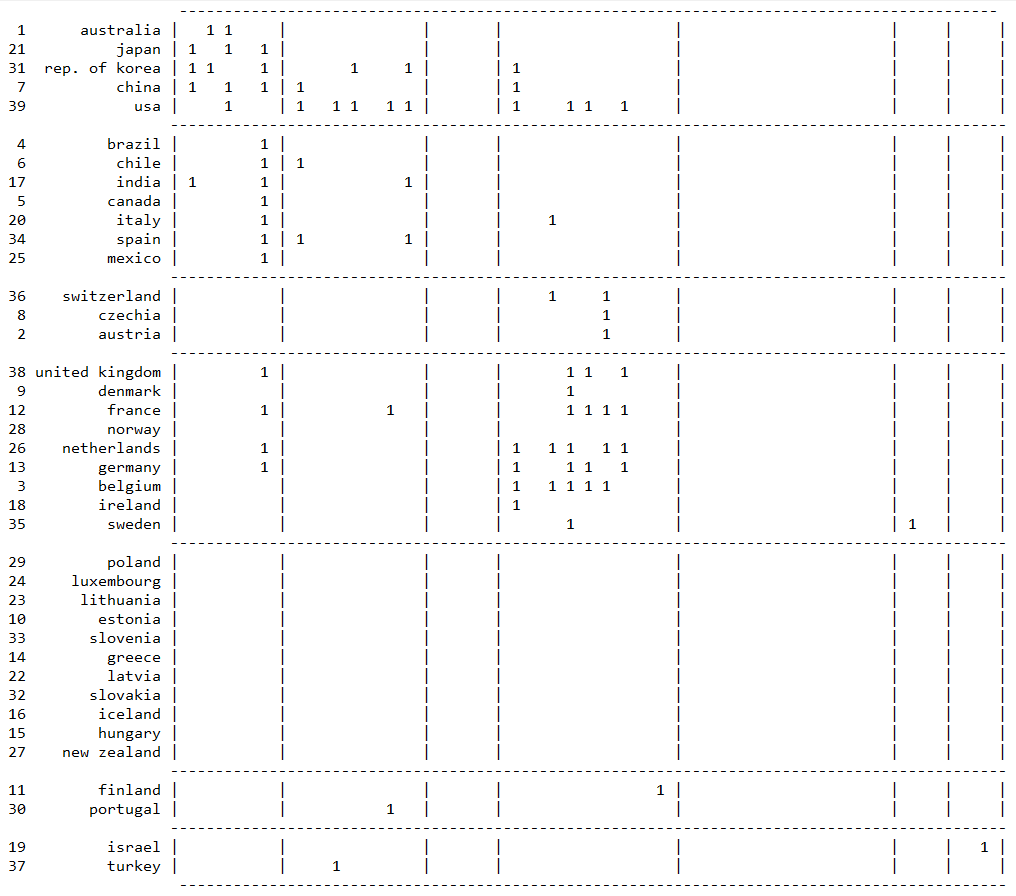


Figure 17 CONCOR Block Model for Manufacturing – 2018

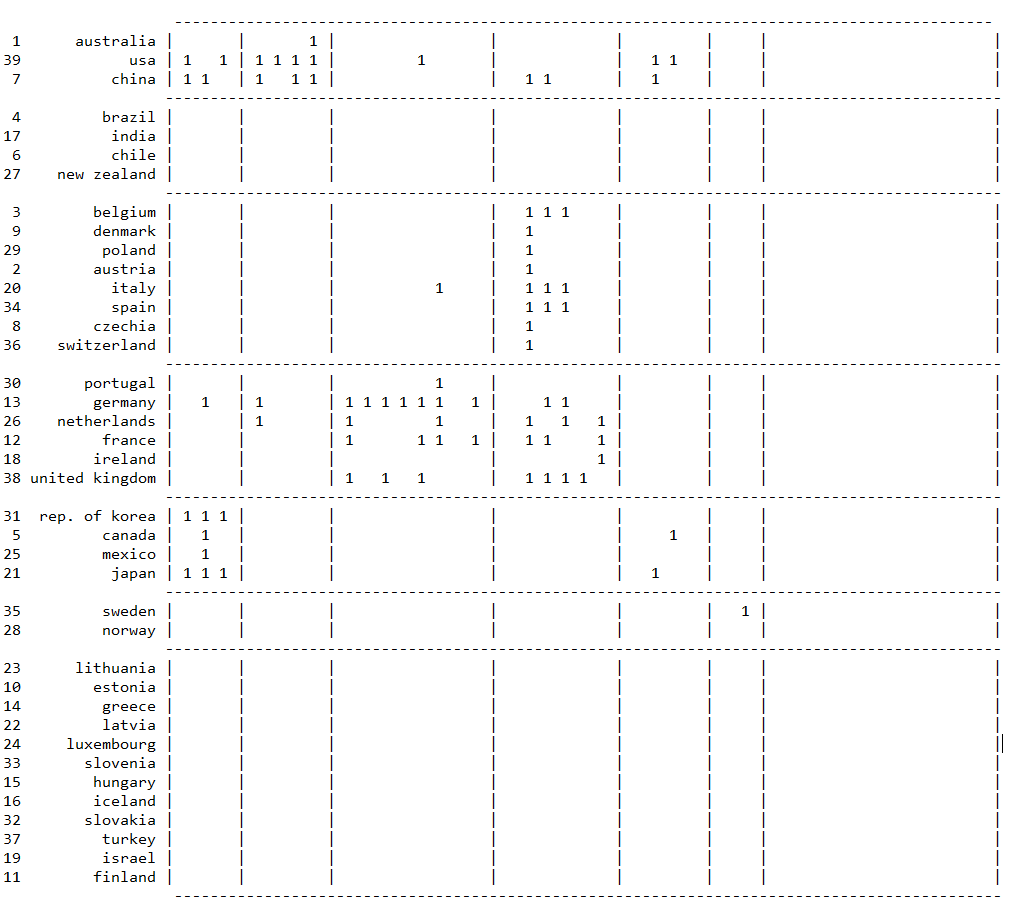


Figure 18 CONCOR Block Model for Agriculture Products – 2018

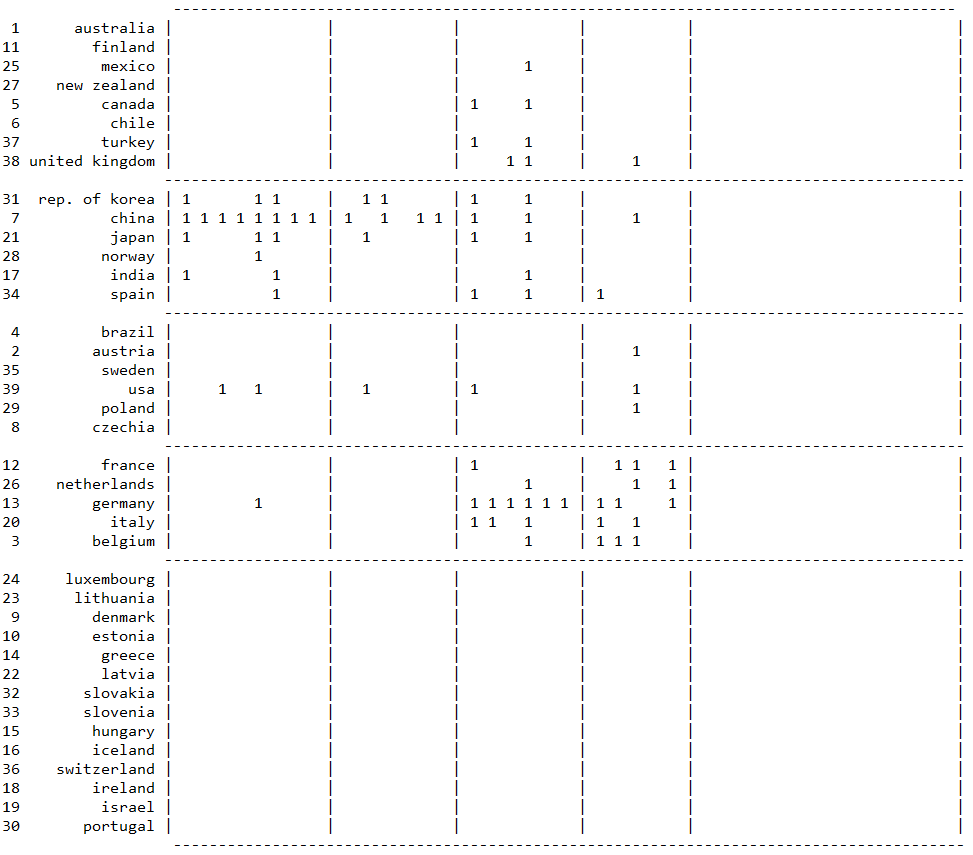


Figure 19 CONCOR Block Model for Raw Materials – 2018

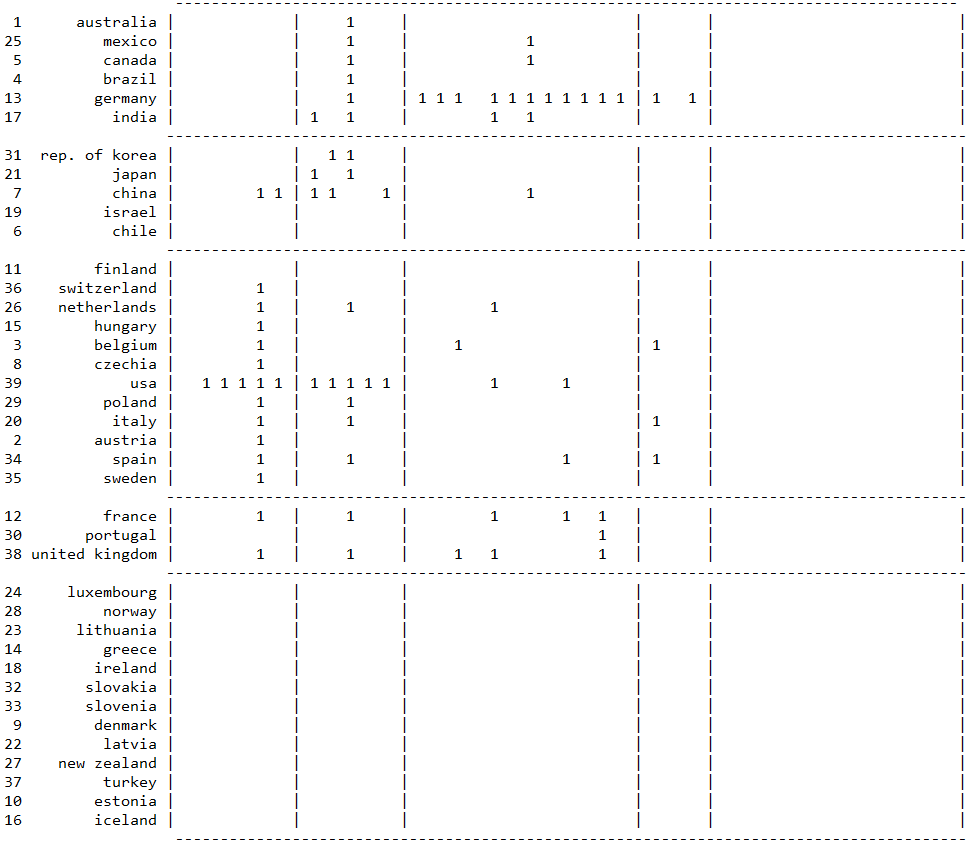


Figure 20 CONCOR Block Model for Energy Products – 2018

## 2008: Binarized for each trade networks

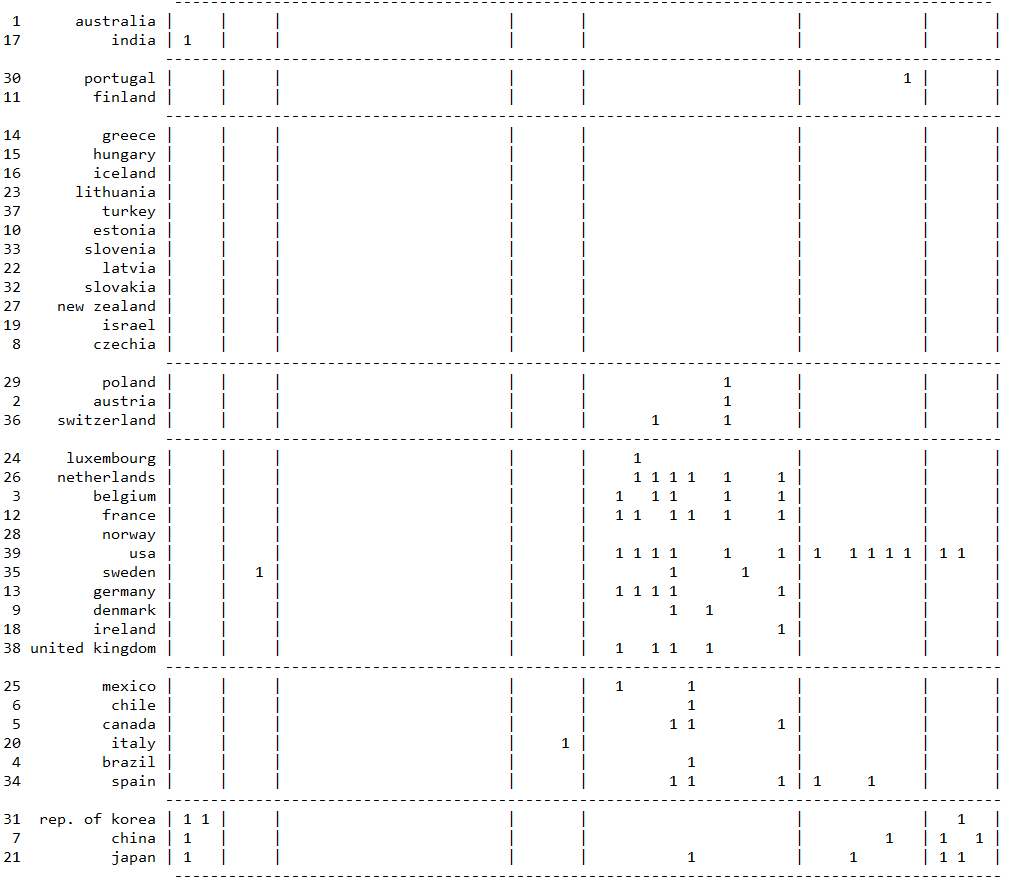


Figure 21 CONCOR Block Model for Manufacturing – 2008

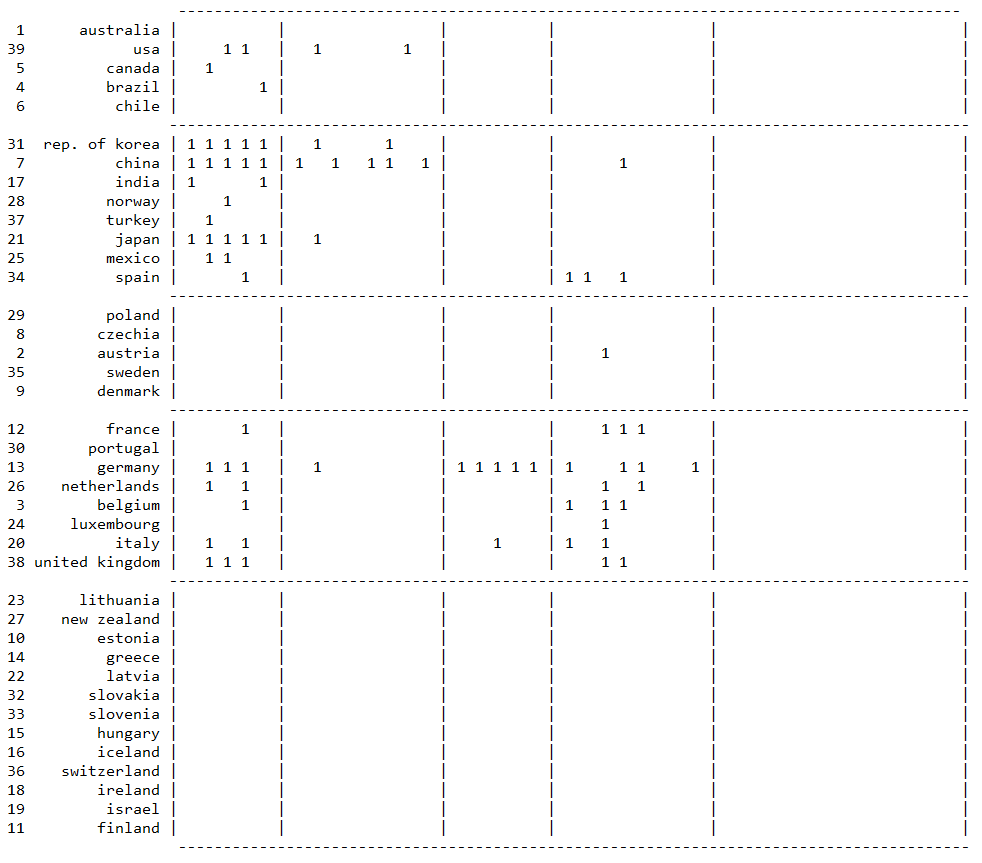


Figure 22 CONCOR Block Model for Raw Materials - 2008

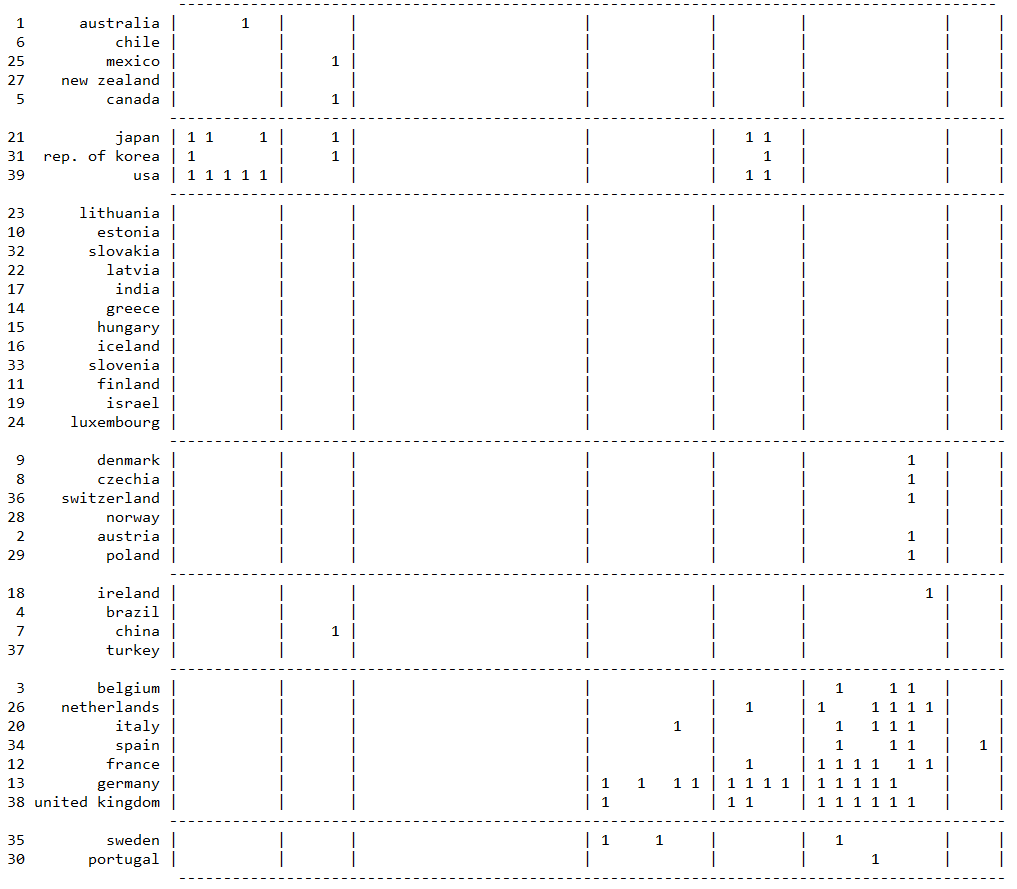


Figure 23 CONCOR Block Model for Agricultural Products – 2008

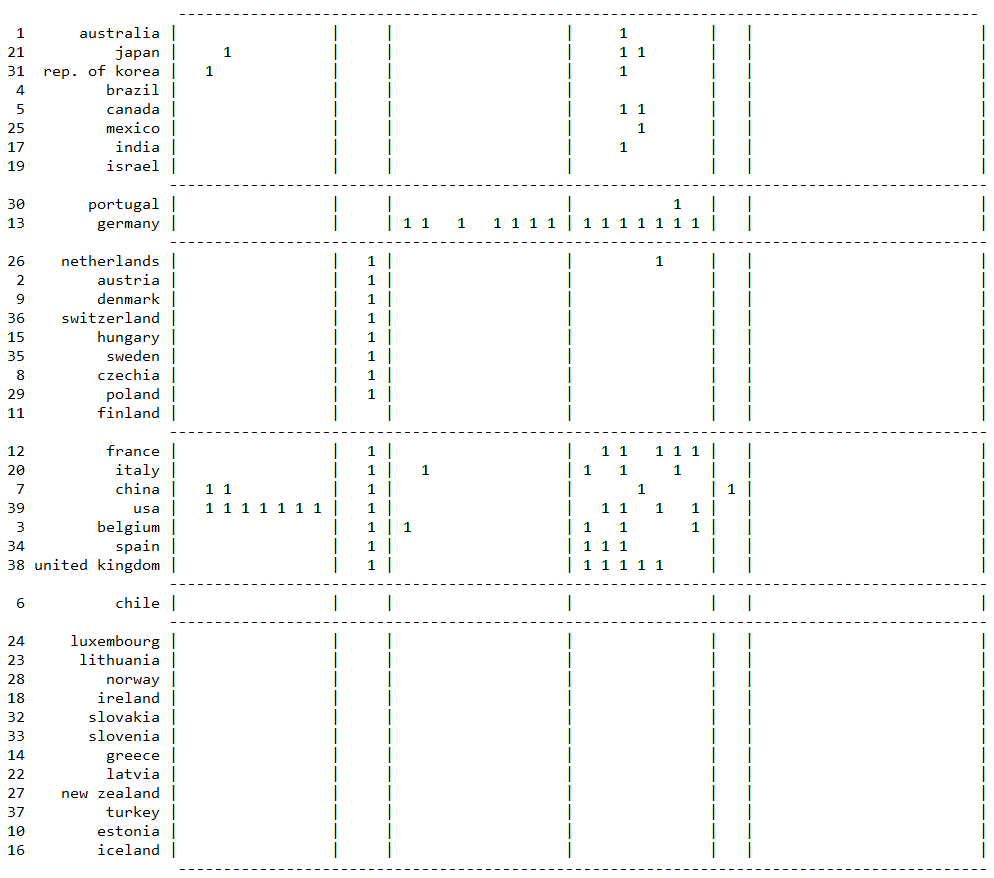


Figure 24 CONCOR Block Model for Energy Products – 2008

## 2007: Binarized for each trade networks

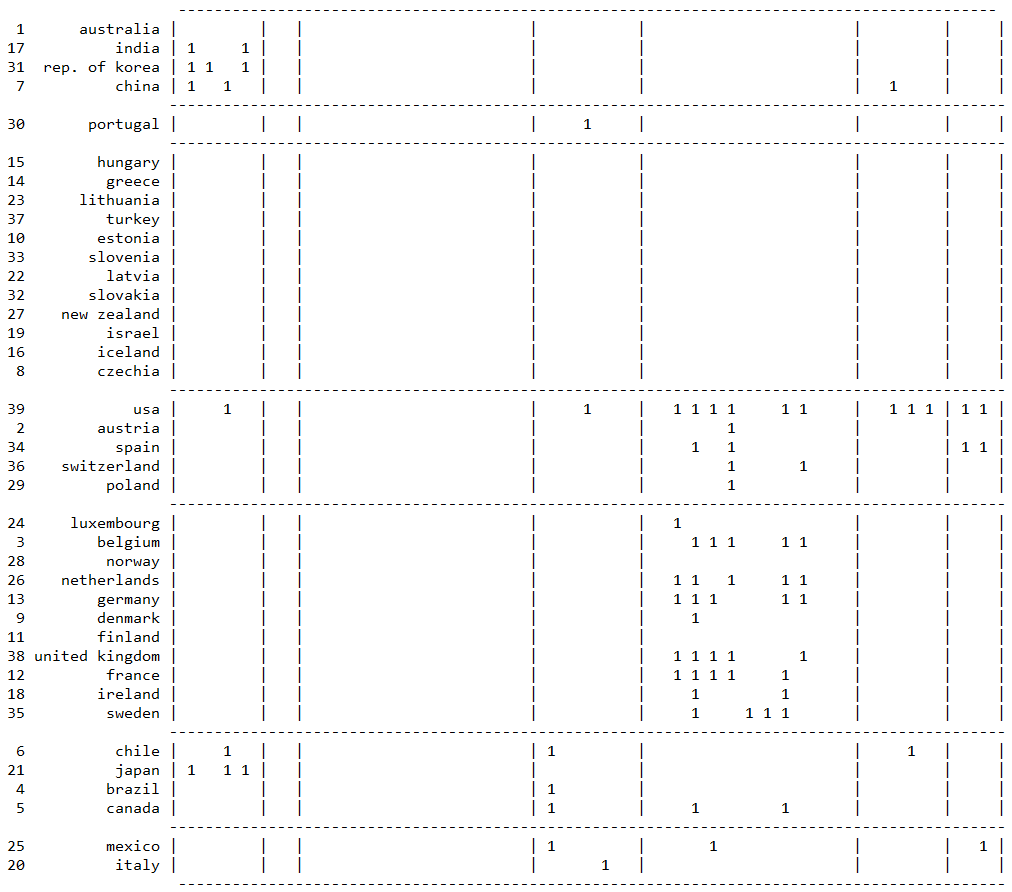


Figure 25 CONCOR Block Model for Manufacturing – 2007

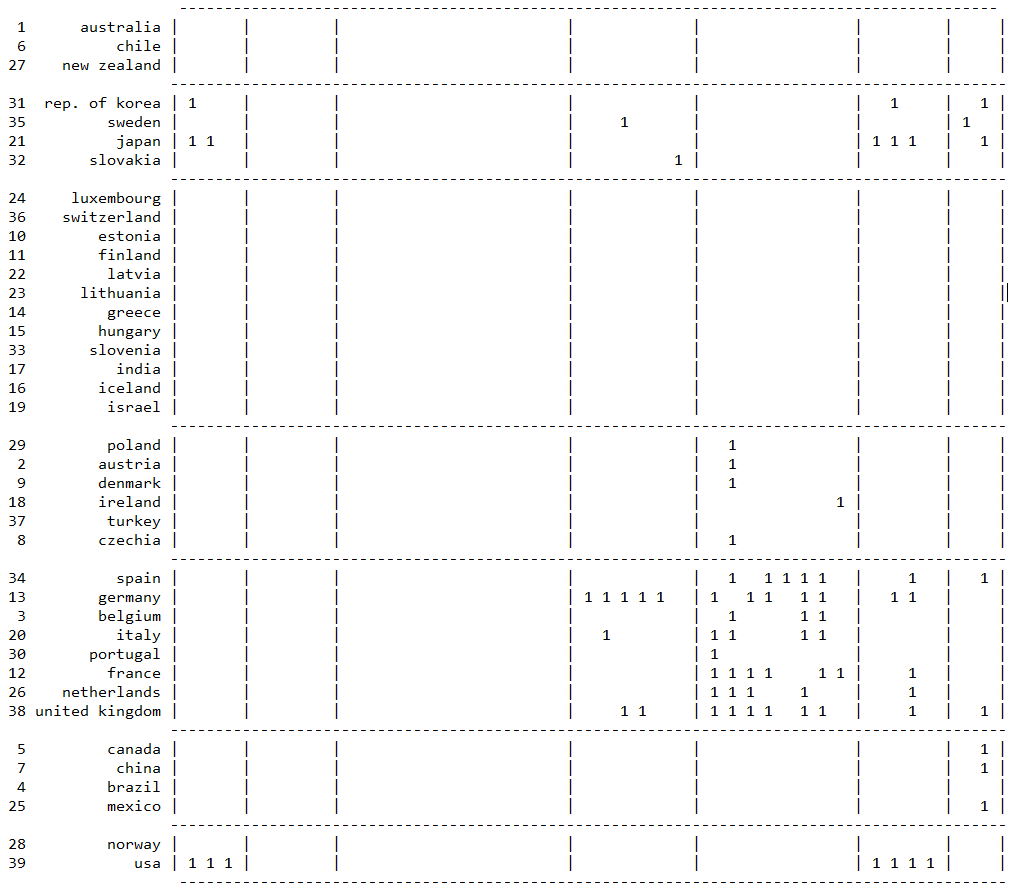


Figure 26 CONCOR Block Model for Agriculture Products – 2007

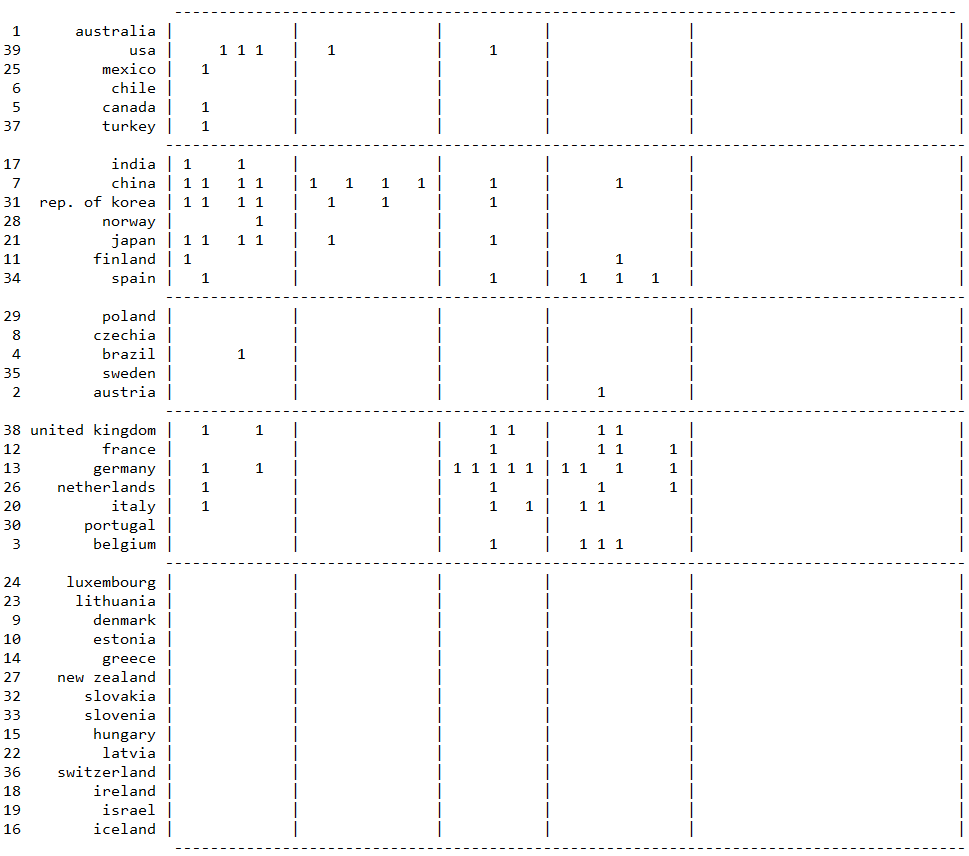


Figure 27 CONCOR Block Model for Raw Materials – 2007

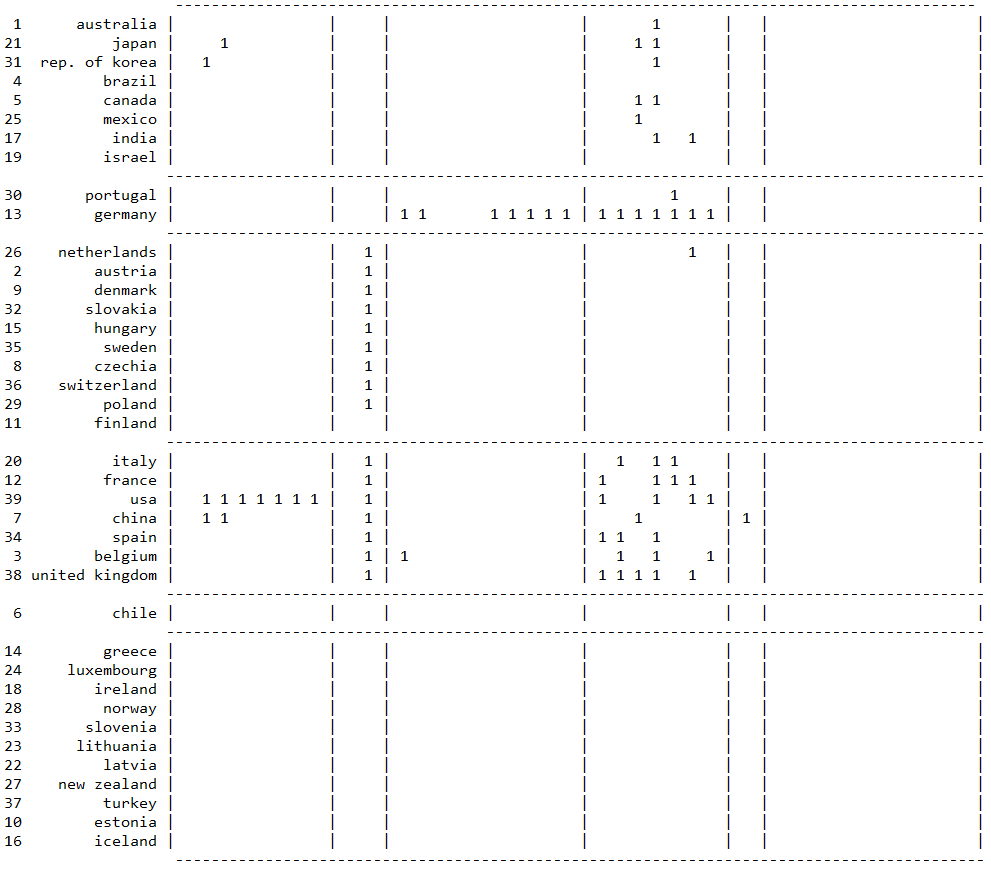


Figure 28 CONCOR Block Model for Energy Products – 2007

## 2013: Binarized for each trade networks

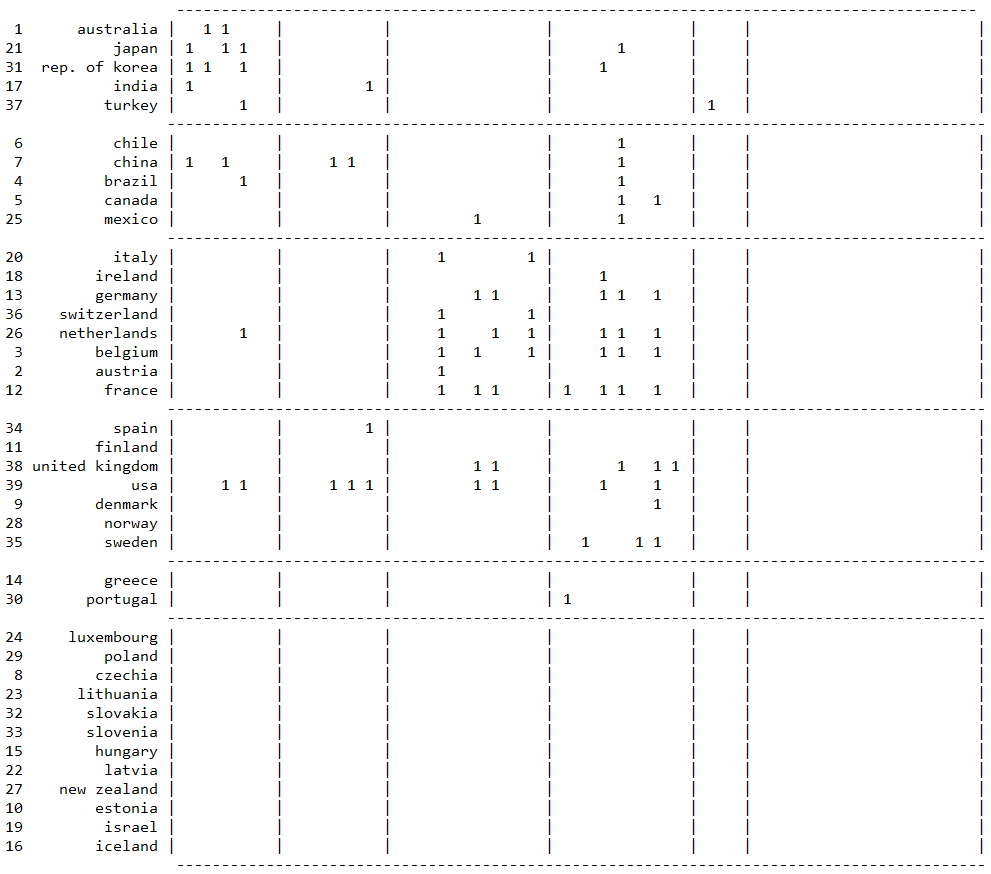


Figure 29 CONCOR Block Model for Manufacturing – 2013

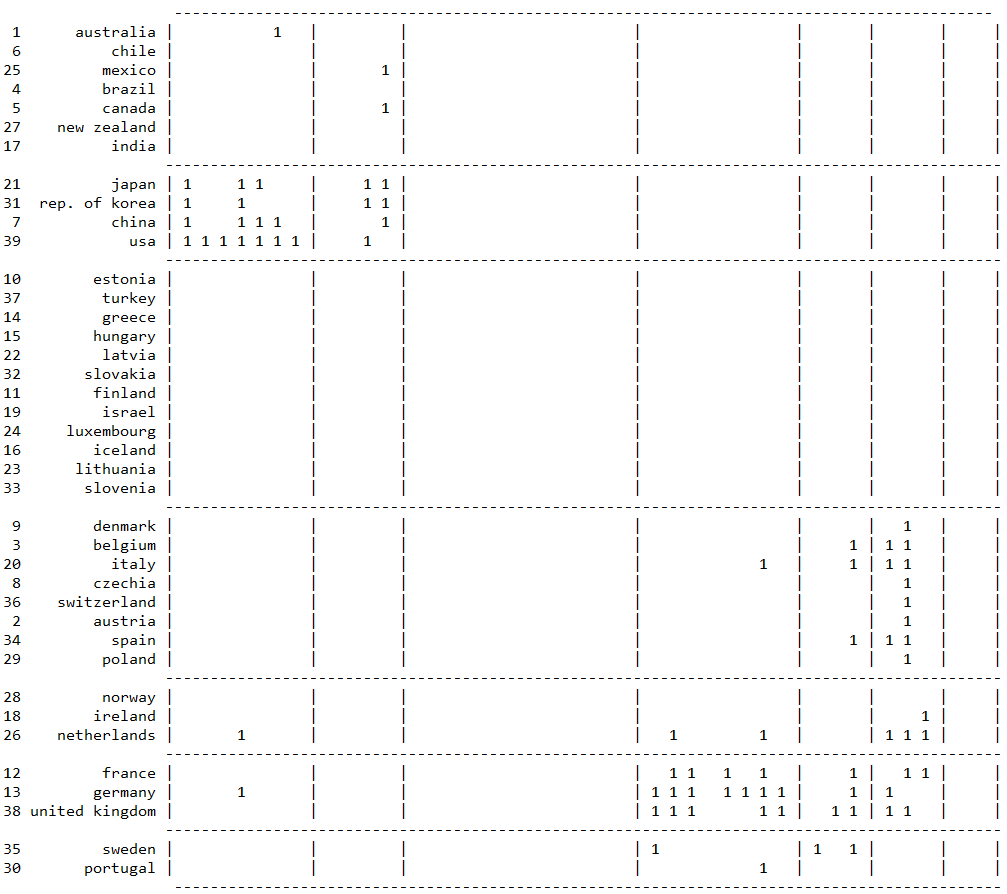


Figure 30 CONCOR Block Model for Agriculture Products – 2013

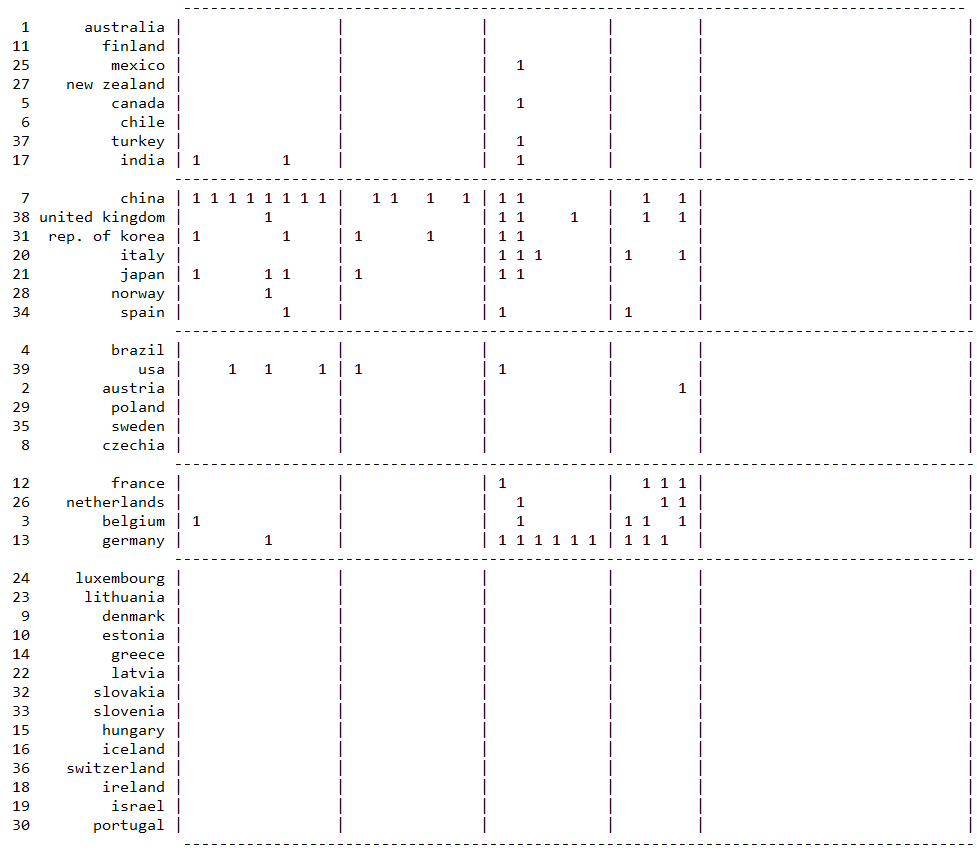


Figure 31 CONCOR Block Model for Raw Materials – 2013

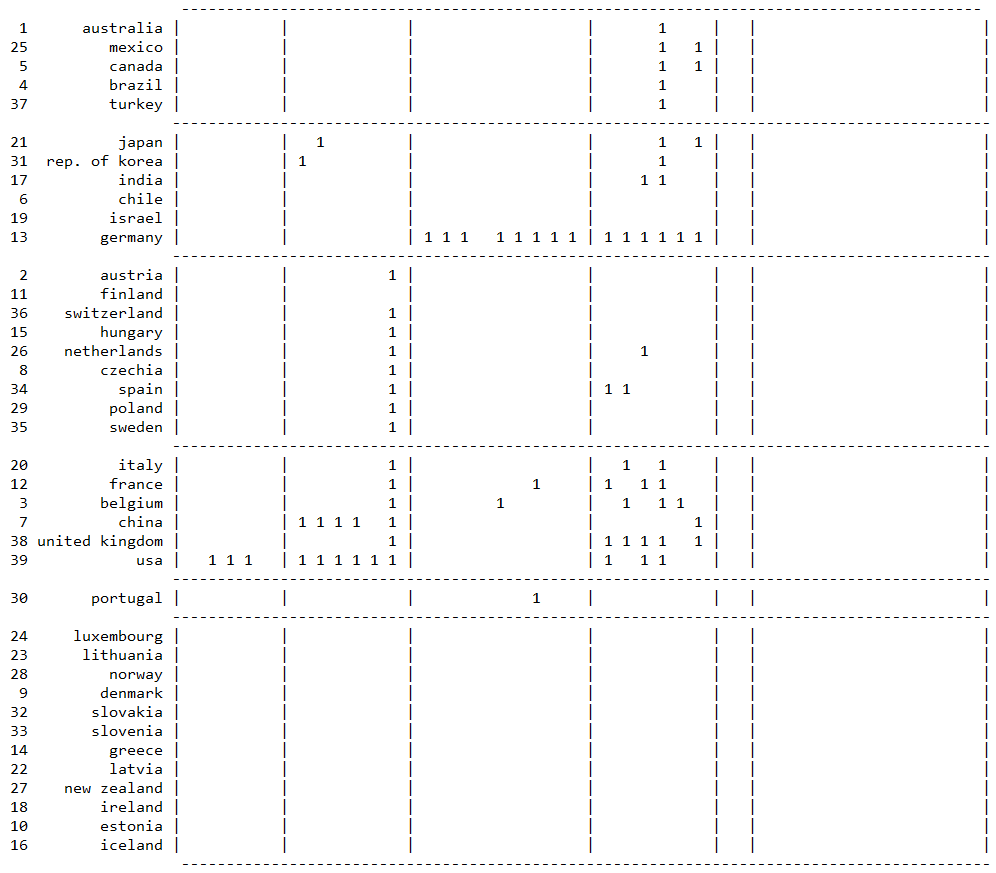


Figure 32 CONCOR Block Model for Energy Products – 2013

## Density Matrix for All Networks for All Years



Figure 33 Density Networks for Multinetwork Analysis

## Breiger’s Results

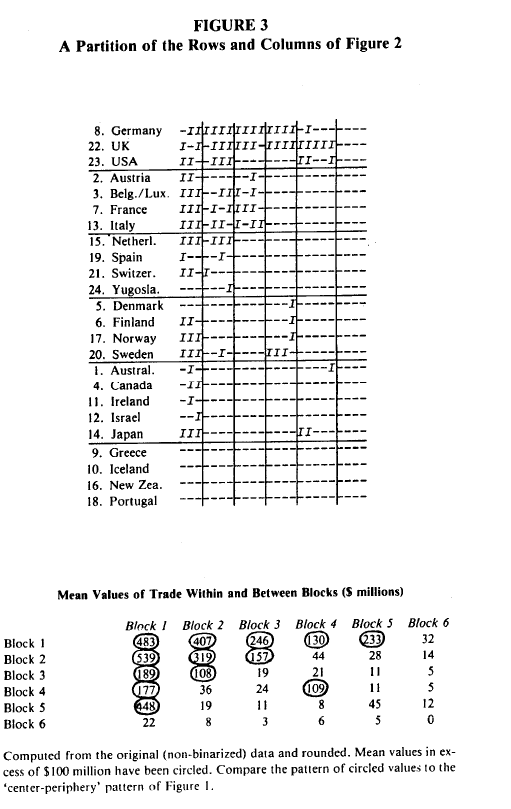
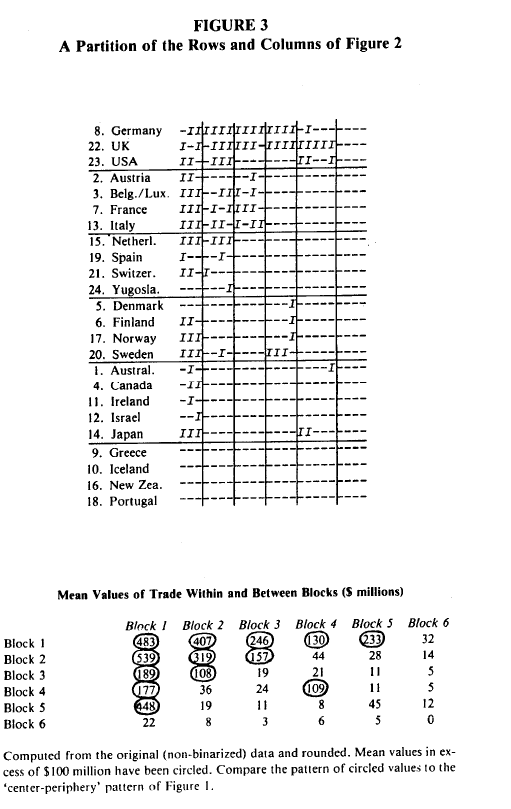


Figure 34 Results of Binarized Manufacture Network Data by Breiger

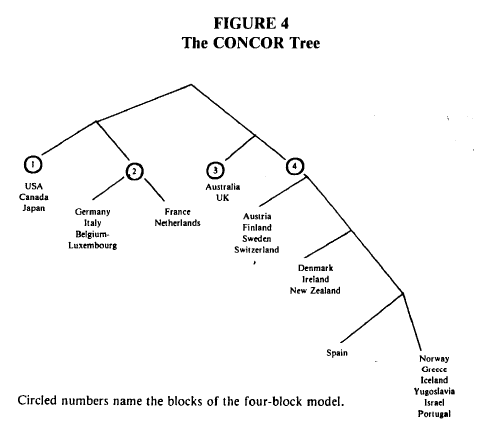


Figure 35 Concor Tree From Breiger's Result

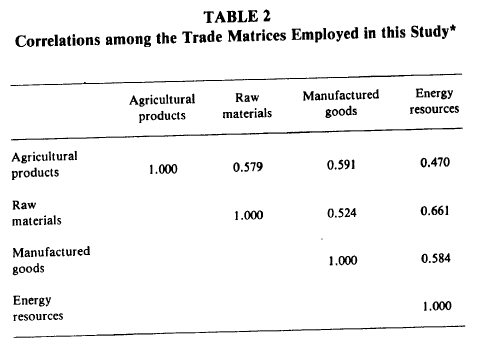


Figure 36 Correlations Matrix from Breiger's Study