

INFX 576: Problem Set 5 - Cohesive Groups and Graph Sets*

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Due: Thursday, February 16, 2017

Collaborators:

Instructions:

Before beginning this assignment, please ensure you have access to R and RStudio.

1. Download the `problemset5.Rmd` file from Canvas. You will also need the data from last week's Problem Set 4 in `problemset4_data.Rdata`.
2. Replace the "Insert Your Name Here" text in the `author:` field with your own full name. Any collaborators must be listed on the top of your assignment.
3. Be sure to include well-documented (e.g. commented) code chunks, figures and clearly written text chunk explanations as necessary. Any figures should be clearly labeled and appropriately referenced within the text.
4. Collaboration on problem sets is acceptable, and even encouraged, but each student must turn in an individual write-up in his or her own words and his or her own work. The names of all collaborators must be listed on each assignment. Do not copy-and-paste from other students' responses or code.
5. When you have completed the assignment and have **checked** that your code both runs in the Console and knits correctly when you click **Knit PDF**, rename the R Markdown file to `YourLastName_YourFirstName_ps5.Rmd`, knit a PDF and submit the PDF file on Canvas.

Setup:

In this problem set you will need, at minimum, the following R packages.

```
# Load standard libraries
library(statnet)
load("problemset4_data.Rdata")
```

Problem 1: Cohesive Subgroups

In this problem we use data collected by Krackhardt (1987), `kfr` capturing self-reported friendship ties among 21 managers in a high-tech firm. This data is directed and unvalued, it is possible for i to nominate j as a friend without reciprocation.

(a) Cliques

Using the `clique.census` command, perform the following analyses on `kfr`:

- Obtain a length-tabulation of clique membership by vertex.
- Obtain the combined clique co-membership matrix.

*Problems originally written by C.T. Butts (2009)

- Use the clique co-membership matrix to obtain a cohesion-based blockmodel of `kfr`. You may find the commands `hclust`, `cutree` and `blockmodel` helpful here. Show the dendrogram (with cutoff value), block image matrix, and block image.

```
Census_clique <- clique.census(kfr, mode = "digraph", tabulate.by.vertex = TRUE, clique.comembership =
Census_clique
```

```
## $clique.count
##   Agg v1 v2 v3 v4 v5 v6 v7 v8 v9 v10 v11 v12 v13 v14 v15 v16 v17 v18 v19
## 1   4  0  0  0  0  0  0  1  0  1  1  0  0  0  0  0  0  0  0  0
## 2   9  2  3  1  1  0  1  0  1  0  0  1  0  1  1  1  1  1  1  1
## 3   6  1  0  0  2  2  0  0  0  0  0  3  3  0  0  1  0  3  0  2
##   v20 v21
## 1     1  0
## 2     0  1
## 3     0  1
##
## $clique.comemb
##      v1 v2 v3 v4 v5 v6 v7 v8 v9 v10 v11 v12 v13 v14 v15 v16 v17 v18 v19 v20
## v1    3  1  0  1  0  0  0  0  0  0  0  1  0  0  0  1  0  0  0  0
## v2    1  3  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  1  0  0
## v3    0  0  1  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  1  0
## v4    1  0  0  3  0  0  0  1  0  0  0  2  0  0  0  0  1  0  0  0
## v5    0  0  0  0  2  0  0  0  0  0  2  0  0  0  0  0  1  0  1  0
## v6    0  0  0  0  0  1  0  0  0  0  0  0  0  0  0  0  1  0  0  0
## v7    0  0  0  0  0  0  1  0  0  0  0  0  0  0  0  0  0  0  0  0
## v8    0  0  0  1  0  0  0  1  0  0  0  0  0  0  0  0  0  0  0  0
## v9    0  0  0  0  0  0  0  0  1  0  0  0  0  0  0  0  0  0  0  0
## v10   0  0  0  0  0  0  0  0  0  1  0  0  0  0  0  0  0  0  0  0
## v11   0  0  0  0  2  0  0  0  0  0  4  0  1  0  1  0  1  0  2  0
## v12   1  0  0  2  0  0  0  0  0  0  0  3  0  0  0  0  2  0  0  0
## v13   0  0  0  0  0  0  0  0  0  0  1  0  1  0  0  0  0  0  0  0
## v14   0  0  0  0  0  0  0  0  0  0  0  0  0  1  1  0  0  0  0  0
## v15   0  0  0  0  0  0  0  0  0  0  1  0  0  1  2  0  0  0  1  0
## v16   1  0  0  0  0  0  0  0  0  0  0  0  0  0  0  1  0  0  0  0
## v17   0  0  0  1  1  1  0  0  0  0  1  2  0  0  0  0  4  0  0  0
## v18   0  1  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  1  0  0
## v19   0  0  1  0  1  0  0  0  0  0  2  0  0  0  1  0  0  0  3  0
## v20   0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  1
## v21   0  1  0  0  0  0  0  0  0  0  0  1  0  0  0  0  1  0  0  0
##      v21
## v1      0
## v2      1
## v3      0
## v4      0
## v5      0
## v6      0
## v7      0
## v8      0
## v9      0
## v10     0
## v11     0
## v12     1
## v13     0
## v14     0
```

```

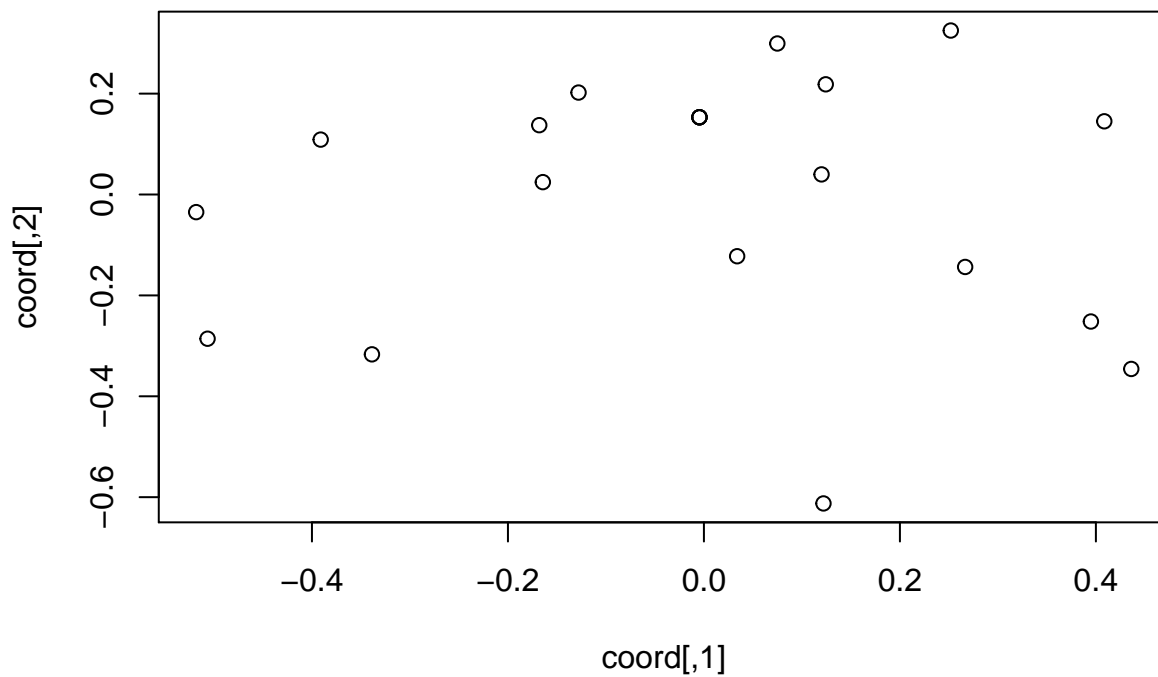
## v15    0
## v16    0
## v17    1
## v18    0
## v19    0
## v20    0
## v21    2
##
## $cliques
## $cliques[[1]]
## $cliques[[1]][[1]]
## [1] 20
##
## $cliques[[1]][[2]]
## [1] 10
##
## $cliques[[1]][[3]]
## [1] 9
##
## $cliques[[1]][[4]]
## [1] 7
##
##
## $cliques[[2]]
## $cliques[[2]][[1]]
## [1] 2 21
##
## $cliques[[2]][[2]]
## [1] 2 18
##
## $cliques[[2]][[3]]
## [1] 1 16
##
## $cliques[[2]][[4]]
## [1] 14 15
##
## $cliques[[2]][[5]]
## [1] 6 17
##
## $cliques[[2]][[6]]
## [1] 11 13
##
## $cliques[[2]][[7]]
## [1] 4 8
##
## $cliques[[2]][[8]]
## [1] 3 19
##
## $cliques[[2]][[9]]
## [1] 1 2
##
##
## $cliques[[3]]
## $cliques[[3]][[1]]

```

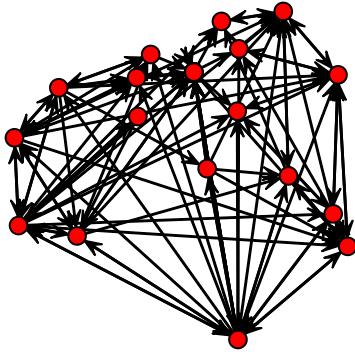
```
## [1] 5 11 19
##
## $cliques[[3]][[2]]
## [1] 11 15 19
##
## $cliques[[3]][[3]]
## [1] 5 11 17
##
## $cliques[[3]][[4]]
## [1] 12 17 21
##
## $cliques[[3]][[5]]
## [1] 4 12 17
##
## $cliques[[3]][[6]]
## [1] 1 4 12
```

```
clique_memb <- Census_clique$clique.count
clique_comemb <- Census_clique$clique.comemb
```

```
# Transforming co-membership to a distance matrix
coord <- cmdscale(1/(1+clique_comemb)) # Perform an MDS
plot(coord)
```

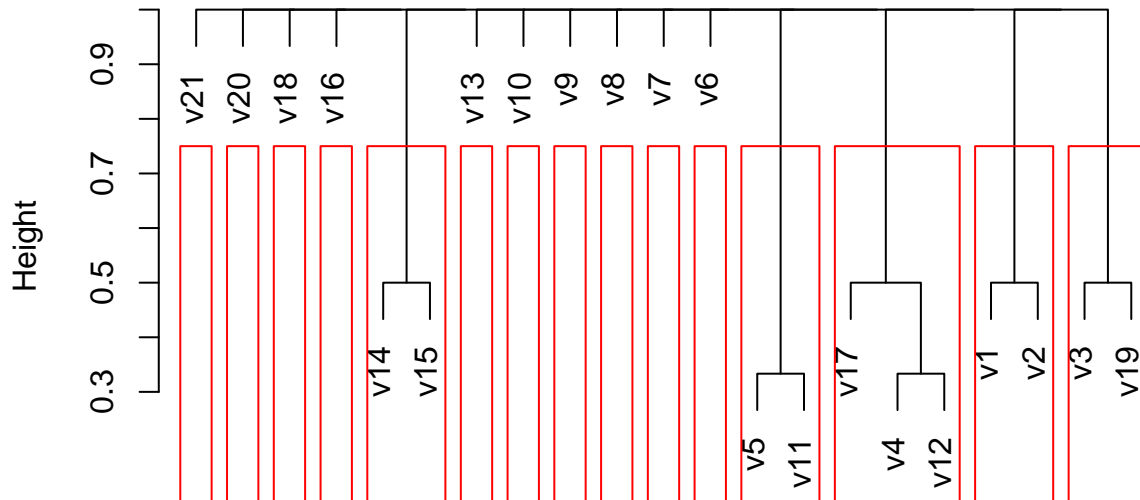


```
gplot(kfr, coord = coord)
```



```
#Clustering
hc <- hclust(as.dist(1/(1+clique_comemb)))
plot(hc)
rect.hclust(hc,h=0.8) # Plot a cutoff point
```

Cluster Dendrogram

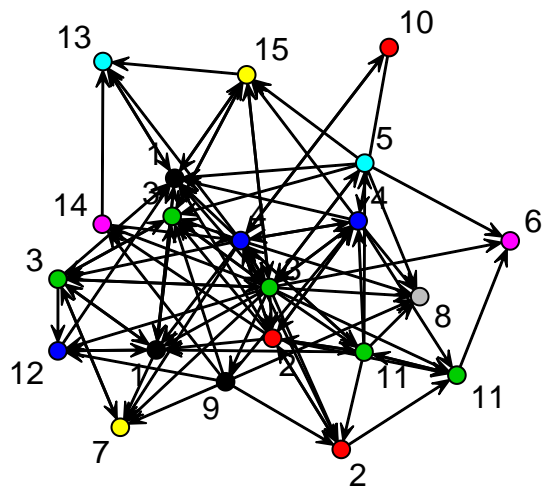


```
as.dist(1/(1 + clique_comemb))
hclust (*, "complete")
```

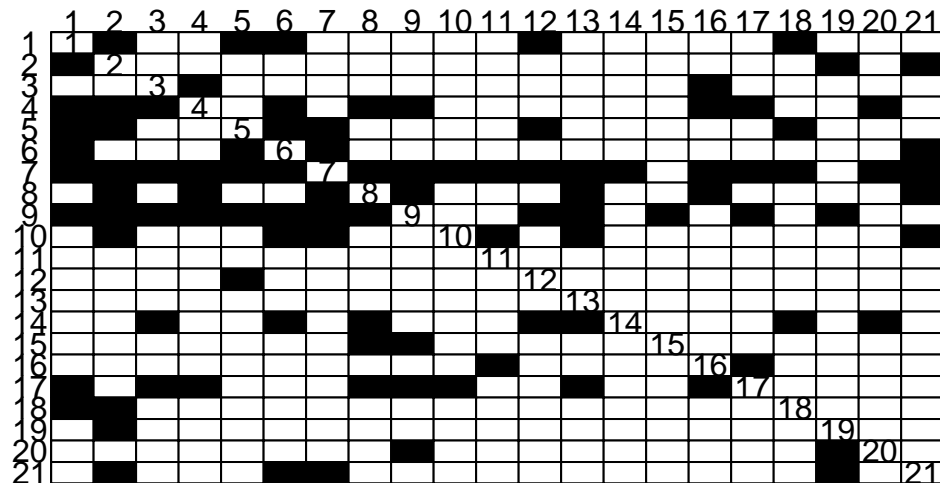
```
ct<-cutree(hc,h=0.8)
ct # Cut the clusters

## v1 v2 v3 v4 v5 v6 v7 v8 v9 v10 v11 v12 v13 v14 v15 v16 v17 v18
## 1 1 2 3 4 5 6 7 8 9 4 3 10 11 11 12 3 13
## v19 v20 v21
## 2 14 15

gplot(kfr,vertex.col=ct, label = ct) # Visualize directly
```



```
plot.sociomatrix(kfr[order(ct),order(ct)])
```



```
#Block model
bm <- blockmodel(kfr, ct)                                     # Block image matrix
bm
```

```
##
## Network Blockmodel:
##
## Block membership:
##
##  1  2  3  4  5  6  7  8  9 10 11 12 13 14 15 16 17 18 19 20 21
##  1  1  2  3  4  5  6  7  8  9  4  3 10 11 11 12  3 13  2 14 15
##
## Reduced form blockmodel:
##
##   1  2  3  4  5  6  7  8  9 10 11 12 13 14 15 16 17 18 19 20 21
##
##           Block 1  Block 2  Block 3  Block 4  Block 5  Block 6
## Block 1  1.0000000 0.0000000 0.3333333 0.0000000 0.0000000 0.0000000
## Block 2  0.5000000 1.0000000 0.1666667 0.5000000 0.0000000 0.0000000
## Block 3  0.8333333 0.3333333 1.0000000 0.3333333 0.3333333 0.3333333
## Block 4  0.7500000 0.7500000 0.6666667 1.0000000 0.0000000 0.0000000
## Block 5  0.5000000 0.0000000 0.6666667 0.0000000      NaN 1.0000000
```

```

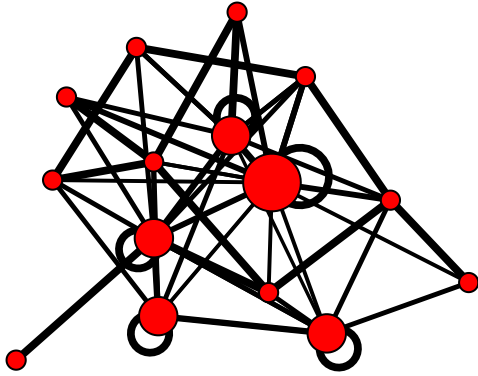
## Block 6  0.0000000 0.0000000 0.0000000 0.0000000 0.0000000      NaN
## Block 7  0.0000000 0.0000000 0.3333333 0.0000000 0.0000000 0.0000000
## Block 8  0.0000000 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000
## Block 9  0.0000000 0.5000000 0.3333333 0.5000000 0.0000000 0.0000000
## Block 10 0.0000000 0.0000000 0.0000000 1.0000000 0.0000000 0.0000000
## Block 11 0.2500000 0.5000000 0.0000000 0.5000000 0.5000000 0.5000000
## Block 12 1.0000000 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000
## Block 13 0.5000000 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000
## Block 14 0.0000000 0.0000000 0.0000000 0.5000000 0.0000000 0.0000000
## Block 15 0.5000000 0.0000000 0.6666667 0.0000000 0.0000000 0.0000000
##          Block 7  Block 8  Block 9 Block 10  Block 11  Block 12
## Block 1  0.5000000 0.0000000 0.0000000      0.0 0.0000000 0.5000000
## Block 2  0.0000000 0.0000000 0.0000000      0.0 0.7500000 0.0000000
## Block 3  0.6666667 0.3333333 0.3333333      0.0 0.3333333 0.6666667
## Block 4  0.5000000 1.0000000 0.0000000      0.5 0.5000000 0.0000000
## Block 5  0.0000000 1.0000000 0.0000000      0.0 0.0000000 0.0000000
## Block 6  0.0000000 0.0000000 0.0000000      0.0 0.0000000 0.0000000
## Block 7      NaN 0.0000000 0.0000000      0.0 0.0000000 0.0000000
## Block 8  0.0000000      NaN 0.0000000      0.0 0.0000000 0.0000000
## Block 9  1.0000000 1.0000000      NaN      0.0 0.0000000 1.0000000
## Block 10 0.0000000 0.0000000 0.0000000      NaN 0.0000000 0.0000000
## Block 11 0.0000000 0.5000000 0.0000000      0.0 1.0000000 0.0000000
## Block 12 0.0000000 0.0000000 0.0000000      0.0 0.0000000      NaN
## Block 13 0.0000000 0.0000000 0.0000000      0.0 0.0000000 0.0000000
## Block 14 0.0000000 0.0000000 0.0000000      0.0 0.0000000 0.0000000
## Block 15 0.0000000 0.0000000 0.0000000      0.0 0.0000000 0.0000000
##          Block 13  Block 14  Block 15
## Block 1      0.5 0.0000000 0.5000000
## Block 2      0.0 0.5000000 0.0000000
## Block 3      0.0 0.3333333 0.6666667
## Block 4      0.5 0.0000000 0.5000000
## Block 5      0.0 0.0000000 1.0000000
## Block 6      0.0 0.0000000 0.0000000
## Block 7      0.0 0.0000000 0.0000000
## Block 8      0.0 0.0000000 0.0000000
## Block 9      0.0 1.0000000 0.0000000
## Block 10     0.0 0.0000000 0.0000000
## Block 11     0.0 0.0000000 0.0000000
## Block 12     0.0 0.0000000 0.0000000
## Block 13     NaN 0.0000000 0.0000000
## Block 14     1.0      NaN 0.0000000
## Block 15     1.0 0.0000000      NaN

```

```

gplot(bm$block.model,vertex.cex=table(ct),    # Block image.
      edge.lwd=6*bm$block.model, usearrows=FALSE,
      diag=TRUE)

```



(b) K-Cores

Use the `kcores` command to calculate the total degree k -cores of `kfr`. Visualize the network, indicating by size, shape, or color the core number for each vertex.

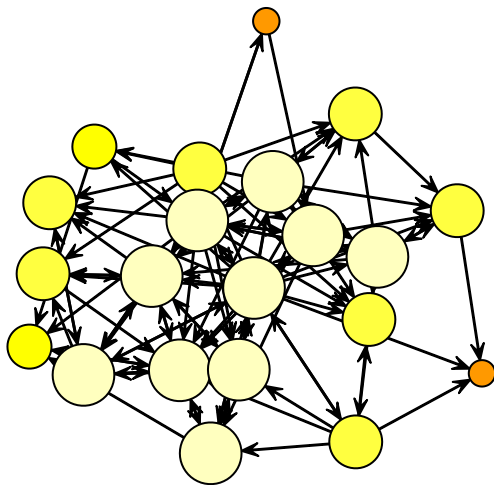
```
kf <- kcores(kfr)
kf
```

```
## 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21
## 7 7 6 7 7 6 3 6 6 6 7 7 3 6 7 6 7 5 7 5 7
```

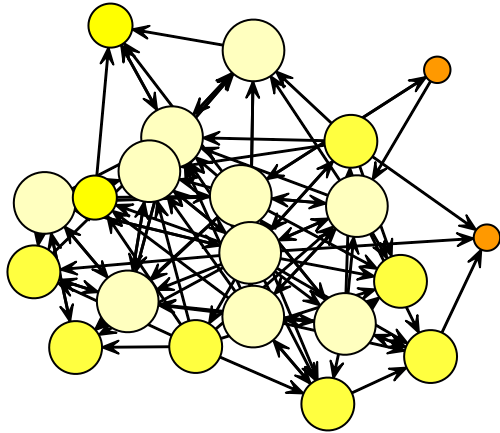
```
table(kf)
```

```
## kf
## 3 5 6 7
## 2 2 7 10
```

```
gplot(kf, vertex.col=heat.colors(max(kf)+1)[kf+1], vertex.cex=(kf/2))
```

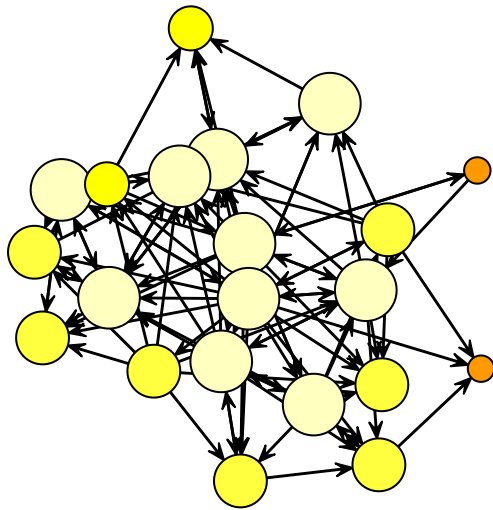


```
gplot(kf, vertex.col=
  heat.colors(max(kf[kf>1])+1)[kf[kf>1]+1], vertex.cex=(kf/2),) # 2-core
```

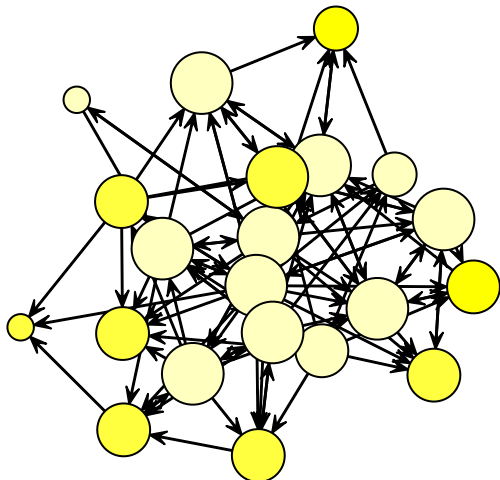
```
gplot(kfr, vertex.col=
  heat.colors(max(kc[kc>2])+1)[kc[kc>2]+1], vertex.cex=(kc/2))
```

3-core



```
gplot(kfr, vertex.col=
  heat.colors(max(kc[kc>3])+1)[kc[kc>3]+1], vertex.cex=(kc/2))
```

4-core



(c) Discussion

Based on the analysis in parts (a) and (b), how would you summarize the structure of this network; in particular, how many distinct dense clusters do there appear to be?

The network structure shows formation of groups or cohesive subgroups. There are few vertices which tend to interact more with few vertices as compared to others. From the analysis in parts (a) and (b), we can see that there are three distinct clusters. In part a, there can be three block models seen, which implies 3 different clusters. In part b, the vertices are clustered based on their k-cores, and the three clusters can be seen due to difference in color and size.

Problem 2: Graph Correlation

Last week, we saw network data from the famous Bernard, Killworth, and Sailer (BKS) studies. These studies examined the issue of accuracy in self-reported network data. Each study involved a group of subjects, each of whom was asked to rank-order all other group members by frequency of interaction. The self-reported interaction frequency was referred to as the “cognitive” network by BKS (i.e. the network as understood by the subjects themselves). During the study period, behavioral information on interaction within the same groups was also collected via trained observers. The network of observed pairwise interaction frequencies was referred to as the “behavioral” network. Accuracy was assessed by comparing the “cognitive” and “behavioral” networks. The BKS studies were controversial and launched a much larger literature on the accuracy of network measurement.

(a) Comparing Networks

For each of the data objects `bkfrat`, `bkham`, `bkoff` and `bktec` (each itself a list containing the cognitive and behavioral network from a BKS study) perform a QAP test of the correlation between the self-report and the observed structure. Show in each case the test results, including a plot of the QAP replicates.

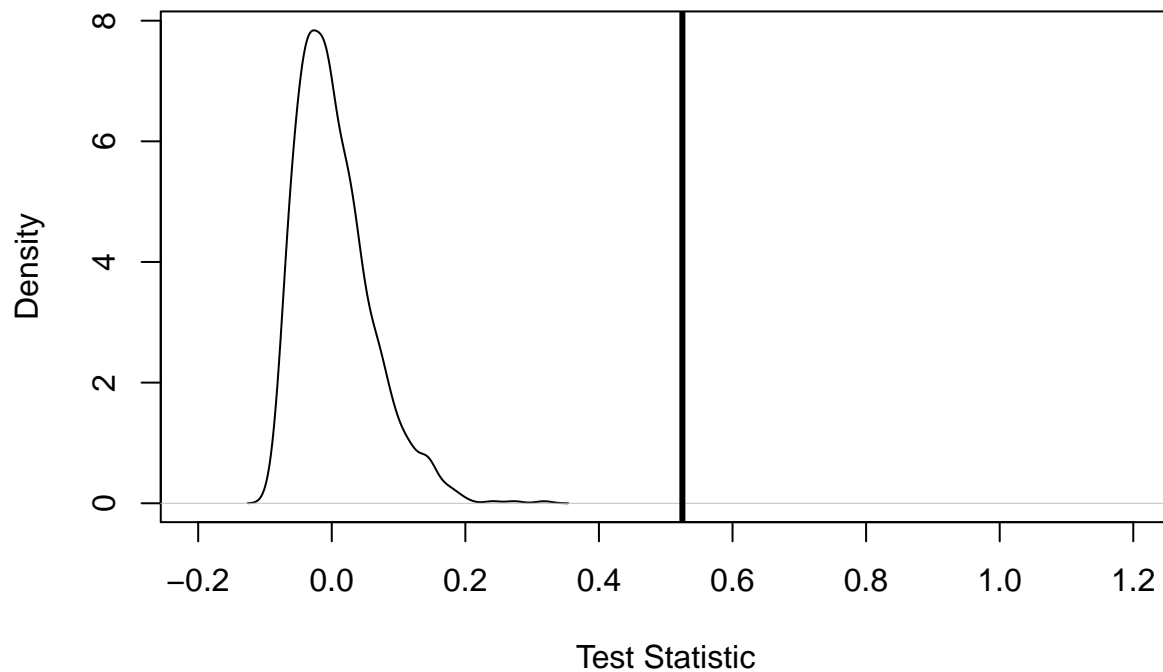
```
load("problemset4_data.Rdata")

#Bkham Network
bkham_beh <- bkham$Behavioral
bkham_cog <- bkham$Cognitive
bkham_qt <- qaptest(list(bkham_beh,bkham_cog), gcor, g1=1,g2=2)
summary(bkham_qt)

##
## QAP Test Results
##
## Estimated p-values:
## p(f(perm) >= f(d)): 0
## p(f(perm) <= f(d)): 1
##
## Test Diagnostics:
## Test Value (f(d)): 0.5249309
## Replications: 1000
## Distribution Summary:
##      Min:      -0.08969635
##      1stQ:     -0.03694152
##      Med:      -0.005867359
##      Mean:      0.004450953
##      3rdQ:      0.03433316
##      Max:       0.3178292

plot(bkham_qt, xlim=c(-0.2,1.2))
abline(v=gcor(bkham_beh,bkham_cog), lwd=3)
```

Estimated Density of QAP Replications

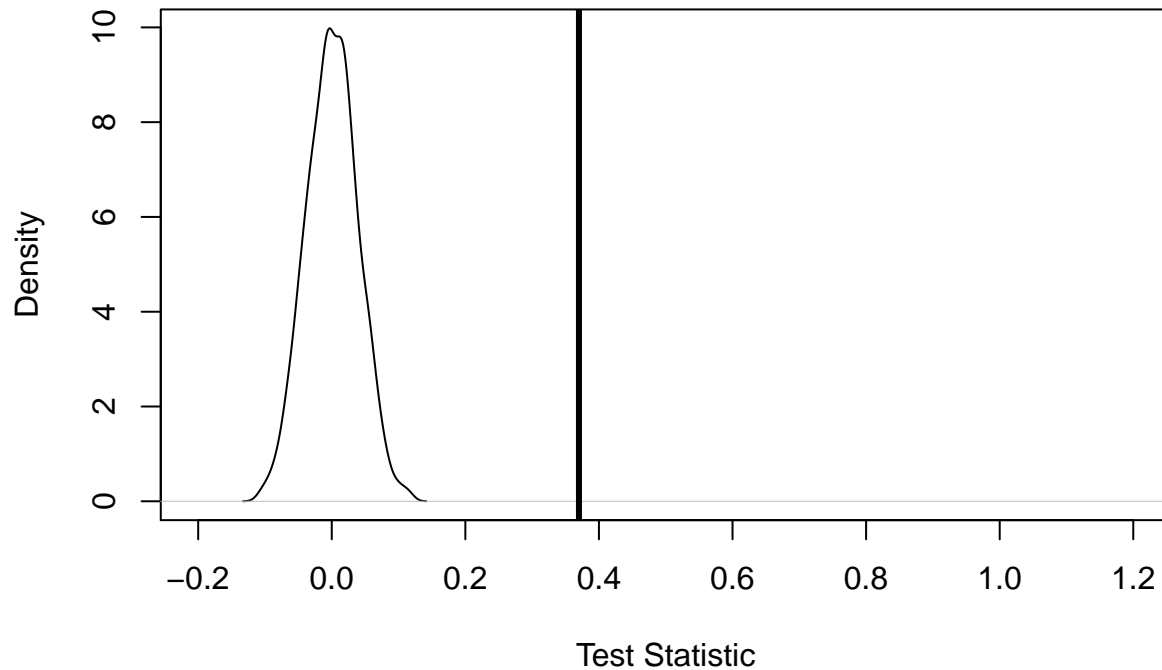


```
#Bkfrat Network
bkfrat_beh <- bkfrat$Behavioral
bkfrat_cog <- bkfrat$Cognitive
bkfrat_qt <- qaptest(list(bkfrat_beh,bkfrat_cog), gcor, g1=1,g2=2)
summary(bkfrat_qt)
```

```
##
## QAP Test Results
##
## Estimated p-values:
## p(f(perm) >= f(d)): 0
## p(f(perm) <= f(d)): 1
##
## Test Diagnostics:
## Test Value (f(d)): 0.3700903
## Replications: 1000
## Distribution Summary:
##      Min:      -0.1068243
##      1stQ:     -0.02585896
##      Med:      0.0003428773
##      Mean:     0.0007095906
##      3rdQ:     0.02669454
##      Max:      0.1153762
```

```
plot(bkfrat_qt, xlim=c(-0.2,1.2))
abline(v=gcor(bkfrat_beh,bkfrat_cog), lwd=3)
```

Estimated Density of QAP Replications

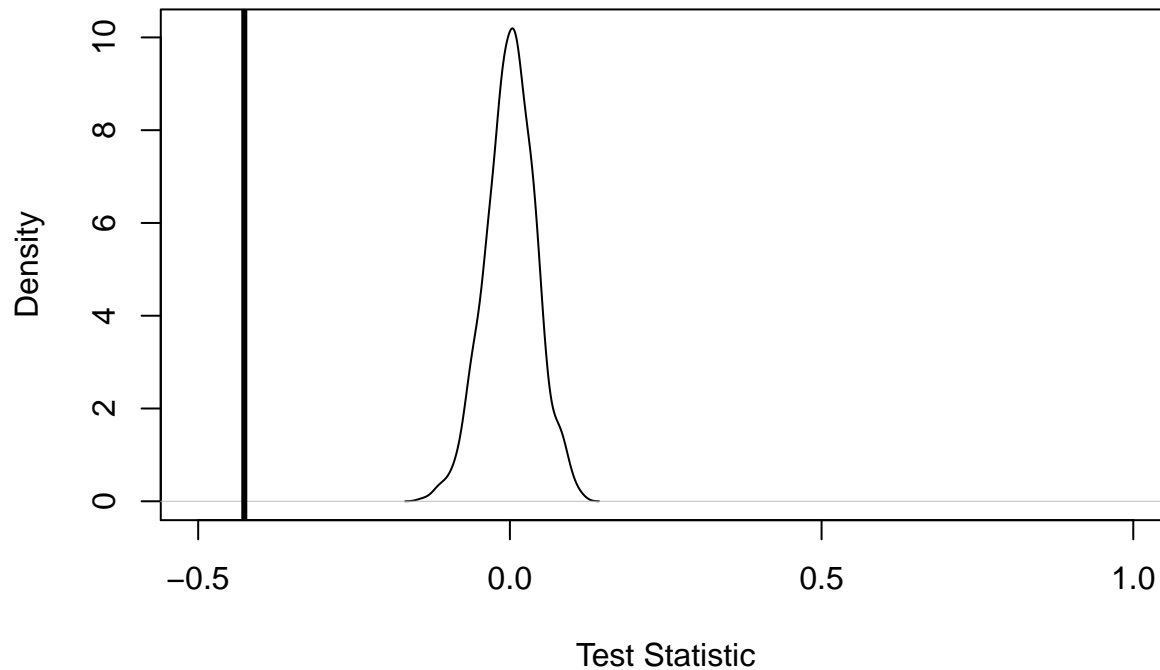


```
#Bktec Network
bktec_beh <- bktec$Behavioral
bktec_cog <- bktec$Cognitive
bktec_qt <- qaptest(list(bktec_beh,bktec_cog), gcor, g1=1,g2=2)
summary(bktec_qt)
```

```
##
## QAP Test Results
##
## Estimated p-values:
## p(f(perm) >= f(d)): 1
## p(f(perm) <= f(d)): 0
##
## Test Diagnostics:
## Test Value (f(d)): -0.4260065
## Replications: 1000
## Distribution Summary:
##      Min:      -0.1412103
##      1stQ:     -0.02533912
##      Med:      0.001984768
##      Mean:     0.0008220204
##      3rdQ:     0.02755265
##      Max:      0.1161872
```

```
plot(bktec_qt, xlim=c(-0.5,1))
abline(v=gcor(bktec_beh,bktec_cog), lwd=3)
```

Estimated Density of QAP Replications

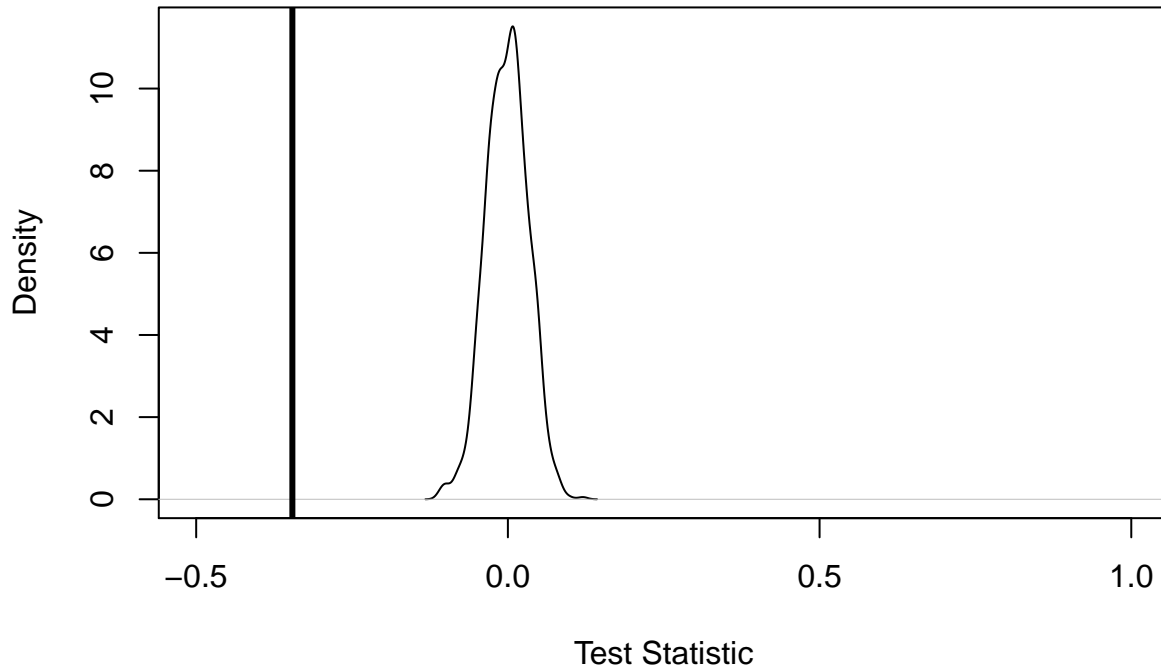


```
#Bkham Network
bkoff_beh <- bkoff$Behavioral
bkoff_cog <- bkoff$Cognitive
bkoff_qt <- qaptest(list(bkoff_beh,bkoff_cog), gcor, g1=1,g2=2)
summary(bkoff_qt)
```

```
##
## QAP Test Results
##
## Estimated p-values:
## p(f(perm) >= f(d)): 1
## p(f(perm) <= f(d)): 0
##
## Test Diagnostics:
## Test Value (f(d)): -0.3457147
## Replications: 1000
## Distribution Summary:
##      Min:      -0.109483
##      1stQ:     -0.02456285
##      Med:      -9.110692e-05
##      Mean:     -0.001296261
##      3rdQ:      0.02171894
##      Max:       0.1202336
```

```
plot(bkoff_qt, xlim=c(-0.5,1))
abline(v=gcor(bkoff_beh,bkoff_cog), lwd=3)
```

Estimated Density of QAP Replications



(b) Discussion

Use the results from part (a) to provide your own assessment of the extent to which the data does or does not show general agreement between observation and informant report.

Bkham network: The observed correlation between the cognitive and behavioral network for the bkham network is 0.524. Since this correlation is much greater than the permutation distribution obtained from the QAP test, this correlation can be considered a strong one. Thus we can say that, there may be agreement between the self-report and observed structure.

Bkfrat Network: The observed correlation between the cognitive and behavioral network for the bkfrat network is 0.37. Since this correlation is much greater than the permutation distribution obtained from the QAP test, this correlation can be considered a strong one. Thus we can say that, there may be agreement between the self-report and observed structure.

Bktec Network: The observed correlation between the cognitive and behavioral network for the bkham network is -0.426. Since this correlation is much lesser than the permutation distribution obtained from the QAP test, this correlation can be considered a weak one. Thus we can say that, there may not be an agreement between the self-report and observed structure.

Bkoff Network: The observed correlation between the cognitive and behavioral network for the bkham network is -0.346. Since this correlation is much lesser than the permutation distribution obtained from the QAP test, this correlation can be considered a strong one. Thus we can say that, there may not be an agreement between the self-report and observed structure.

(c) Observation and Networks

What reliability or validity issues might arise in the BKS studies if the observed report data is taken to be the true “behavioral” network?

If the observed data is taken to be the true network, then there might be reliability and validity issues which may arise. This might be because the observer might note the interactions on a particular day which might be very different from the general interactions between people. This raises question about the validity of the data. Also, the interactions seen by the observer may be due to chance and may not represent actual interactions as perceived by people in the network. This raises question about the reliability of the network.

Problem 3: Multivariate Analysis of Network Sets

For this problem we will use data on international trade, called `trade` in the data for this problem set. This data captures trade in various types of products/materials among countries. You will want to explore the data before answering these questions, to ensure you understand what is present.

```
trade
```

```
## , , ALGERIA
##
##          ALGERIA  ARGENTINA  BRAZIL  CHINA  CZECHOSLOVAKIA
## MINERALS          0          0      1      0          0
## CRUDE_MATERIALS    0          1      1      0          0
## FOODS              0          1      1      1          0
## MANUFACTURED_GOODS  0          1      1      1          1
## DIPLOMATIC_EXCHANGE 0          1      1      1          1
##          ECUADOR  EGYPT  ETHIOPIA  FINLAND  HONDURAS
## MINERALS          0      0          0          0          0
## CRUDE_MATERIALS    0      1          1          1          0
## FOODS              0      1          0          1          0
## MANUFACTURED_GOODS  0      0          0          1          0
## DIPLOMATIC_EXCHANGE 0      0          0          1          0
##          INDONESIA  ISRAEL  JAPAN  LIBERIA  MADAGASCAR
## MINERALS          0          0      1          0          0
## CRUDE_MATERIALS    0          0      1          0          0
## FOODS              1          0      0          0          0
## MANUFACTURED_GOODS  1          0      1          0          0
## DIPLOMATIC_EXCHANGE 1          0      1          0          1
##          NEW_ZEALAND  PAKISTAN  SPAIN  SWITZERLAND  SYRIA
## MINERALS          0          0      1          0          0
## CRUDE_MATERIALS    1          0      1          1          1
## FOODS              1          1      1          1          1
## MANUFACTURED_GOODS  1          0      1          1          0
## DIPLOMATIC_EXCHANGE 0          1      1          1          1
##          THAILAND  UNITED_KINGDOM  UNITED_STATES  YUGOSLAVIA
## MINERALS          0          1          1          1          1
## CRUDE_MATERIALS    0          1          1          1          1
## FOODS              1          1          1          1          1
## MANUFACTURED_GOODS  0          1          1          1          1
## DIPLOMATIC_EXCHANGE 0          1          1          1          1
##
## , , ARGENTINA
##
##          ALGERIA  ARGENTINA  BRAZIL  CHINA  CZECHOSLOVAKIA
## MINERALS          0          0      1      0          0
## CRUDE_MATERIALS    0          0      1      1          0
## FOODS              0          0      1      0          0
## MANUFACTURED_GOODS  0          0      1      1          1
## DIPLOMATIC_EXCHANGE 1          0      1      1          1
```

##	ECUADOR	EGYPT	ETHIOPIA	FINLAND	HONDURAS	
## MINERALS	0	0	0	0	0	
## CRUDE_MATERIALS	0	0	0	1	0	
## FOODS	1	0	0	0	0	
## MANUFACTURED_GOODS	0	0	0	1	0	
## DIPLOMATIC_EXCHANGE	0	1	0	1	1	
##	INDONESIA	ISRAEL	JAPAN	LIBERIA	MADAGASCAR	
## MINERALS	0	0	1	0	0	
## CRUDE_MATERIALS	0	1	1	0	0	
## FOODS	0	1	0	0	0	
## MANUFACTURED_GOODS	0	1	1	0	0	
## DIPLOMATIC_EXCHANGE	1	1	1	0	0	
##	NEW_ZEALAND	PAKISTAN	SPAIN	SWITZERLAND	SYRIA	
## MINERALS	0	0	1	0	0	
## CRUDE_MATERIALS	1	0	1	1	0	
## FOODS	0	0	1	1	0	
## MANUFACTURED_GOODS	0	0	1	1	0	
## DIPLOMATIC_EXCHANGE	0	1	1	1	1	
##	THAILAND	UNITED_KINGDOM	UNITED_STATES	YUGOSLAVIA		
## MINERALS	0	0	1	0		
## CRUDE_MATERIALS	0	0	1	0		
## FOODS	0	0	1	0		
## MANUFACTURED_GOODS	0	0	1	1		
## DIPLOMATIC_EXCHANGE	1	0	1	1		
##						
## , , BRAZIL						
##	ALGERIA	ARGENTINA	BRAZIL	CHINA	CZECHOSLOVAKIA	
## MINERALS	1	1	0	1	0	
## CRUDE_MATERIALS	0	1	0	0	0	
## FOODS	0	1	0	0	1	
## MANUFACTURED_GOODS	0	1	0	1	1	
## DIPLOMATIC_EXCHANGE	1	1	0	1	1	
##	ECUADOR	EGYPT	ETHIOPIA	FINLAND	HONDURAS	
## MINERALS	0	0	0	0	0	
## CRUDE_MATERIALS	0	0	0	0	0	
## FOODS	1	0	0	0	0	
## MANUFACTURED_GOODS	1	0	0	1	0	
## DIPLOMATIC_EXCHANGE	1	1	0	1	1	
##	INDONESIA	ISRAEL	JAPAN	LIBERIA	MADAGASCAR	
## MINERALS	0	0	1	0	0	
## CRUDE_MATERIALS	0	0	1	0	0	
## FOODS	0	1	0	0	0	
## MANUFACTURED_GOODS	0	0	1	0	0	
## DIPLOMATIC_EXCHANGE	1	1	1	0	0	
##	NEW_ZEALAND	PAKISTAN	SPAIN	SWITZERLAND	SYRIA	
## MINERALS	0	0	0	0	0	
## CRUDE_MATERIALS	0	0	1	1	0	
## FOODS	0	0	1	1	0	
## MANUFACTURED_GOODS	0	0	1	1	0	
## DIPLOMATIC_EXCHANGE	0	1	1	1	1	
##	THAILAND	UNITED_KINGDOM	UNITED_STATES	YUGOSLAVIA		
## MINERALS	0	1	1	0		
## CRUDE_MATERIALS	0	1	1	0		

## FOODS	0	1	1	1	
## MANUFACTURED_GOODS	1	1	1	0	
## DIPLOMATIC_EXCHANGE	1	1	1	1	
##					
## , , CHINA					
##					
##	ALGERIA	ARGENTINA	BRAZIL	CHINA	CZECHOSLOVAKIA
## MINERALS	0	0	0	0	0
## CRUDE_MATERIALS	1	1	1	0	0
## FOODS	0	0	1	0	0
## MANUFACTURED_GOODS	1	1	1	0	1
## DIPLOMATIC_EXCHANGE	1	1	1	0	1
##	ECUADOR	EGYPT	ETHIOPIA	FINLAND	HONDURAS
## MINERALS	0	0	0	0	0
## CRUDE_MATERIALS	0	1	0	1	0
## FOODS	0	0	0	0	0
## MANUFACTURED_GOODS	0	0	0	1	0
## DIPLOMATIC_EXCHANGE	1	1	1	1	0
##	INDONESIA	ISRAEL	JAPAN	LIBERIA	MADAGASCAR
## MINERALS	0	0	1	0	0
## CRUDE_MATERIALS	1	0	1	0	0
## FOODS	1	0	1	0	0
## MANUFACTURED_GOODS	1	0	1	0	0
## DIPLOMATIC_EXCHANGE	0	0	1	1	1
##	NEW_ZEALAND	PAKISTAN	SPAIN	SWITZERLAND	SYRIA
## MINERALS	0	0	0	0	0
## CRUDE_MATERIALS	1	1	1	1	0
## FOODS	1	0	1	1	0
## MANUFACTURED_GOODS	1	1	1	1	0
## DIPLOMATIC_EXCHANGE	1	1	1	1	1
##	THAILAND	UNITED_KINGDOM	UNITED_STATES	YUGOSLAVIA	
## MINERALS	0	1	1	1	0
## CRUDE_MATERIALS	1	1	1	1	1
## FOODS	1	1	1	1	1
## MANUFACTURED_GOODS	1	1	1	1	1
## DIPLOMATIC_EXCHANGE	1	1	1	1	1
##					
## , , CZECHOSLOVAKIA					
##					
##	ALGERIA	ARGENTINA	BRAZIL	CHINA	CZECHOSLOVAKIA
## MINERALS	0	0	0	0	0
## CRUDE_MATERIALS	1	1	1	1	0
## FOODS	0	1	1	1	0
## MANUFACTURED_GOODS	1	0	1	1	0
## DIPLOMATIC_EXCHANGE	1	1	1	1	0
##	ECUADOR	EGYPT	ETHIOPIA	FINLAND	HONDURAS
## MINERALS	0	0	0	0	0
## CRUDE_MATERIALS	0	1	1	1	1
## FOODS	1	1	1	1	1
## MANUFACTURED_GOODS	0	1	0	1	0
## DIPLOMATIC_EXCHANGE	1	1	0	1	0
##	INDONESIA	ISRAEL	JAPAN	LIBERIA	MADAGASCAR
## MINERALS	0	0	0	0	0
## CRUDE_MATERIALS	1	0	1	0	0

## FOODS	1	0	1	0	0
## MANUFACTURED_GOODS	1	0	1	0	0
## DIPLOMATIC_EXCHANGE	1	0	1	0	0
##	NEW_ZEALAND	PAKISTAN	SPAIN	SWITZERLAND	SYRIA
## MINERALS	0	0	0	1	0
## CRUDE_MATERIALS	1	1	0	1	1
## FOODS	0	1	1	1	0
## MANUFACTURED_GOODS	0	1	1	1	0
## DIPLOMATIC_EXCHANGE	0	0	1	1	1
##	THAILAND	UNITED_KINGDOM	UNITED_STATES	YUGOSLAVIA	
## MINERALS	0	1	0	1	
## CRUDE_MATERIALS	1	1	1	1	
## FOODS	1	1	1	1	
## MANUFACTURED_GOODS	0	1	1	1	
## DIPLOMATIC_EXCHANGE	0	1	1	1	
##					
## , , ECUADOR					
##					
##	ALGERIA	ARGENTINA	BRAZIL	CHINA	CZECHOSLOVAKIA
## MINERALS	0	0	1	0	0
## CRUDE_MATERIALS	0	1	1	0	0
## FOODS	0	1	0	0	0
## MANUFACTURED_GOODS	0	1	1	0	1
## DIPLOMATIC_EXCHANGE	0	1	1	1	1
##	ECUADOR	EGYPT	ETHIOPIA	FINLAND	HONDURAS
## MINERALS	0	0	0	0	0
## CRUDE_MATERIALS	0	0	0	1	0
## FOODS	0	0	0	0	0
## MANUFACTURED_GOODS	0	0	0	1	0
## DIPLOMATIC_EXCHANGE	0	1	0	0	1
##	INDONESIA	ISRAEL	JAPAN	LIBERIA	MADAGASCAR
## MINERALS	0	0	1	0	0
## CRUDE_MATERIALS	0	1	1	0	0
## FOODS	0	0	0	0	0
## MANUFACTURED_GOODS	0	0	1	0	0
## DIPLOMATIC_EXCHANGE	0	1	1	0	0
##	NEW_ZEALAND	PAKISTAN	SPAIN	SWITZERLAND	SYRIA
## MINERALS	0	0	0	0	0
## CRUDE_MATERIALS	0	0	1	1	0
## FOODS	1	0	1	0	0
## MANUFACTURED_GOODS	0	0	1	1	0
## DIPLOMATIC_EXCHANGE	0	0	1	1	0
##	THAILAND	UNITED_KINGDOM	UNITED_STATES	YUGOSLAVIA	
## MINERALS	0	1	1	0	
## CRUDE_MATERIALS	0	1	1	1	
## FOODS	1	0	1	1	
## MANUFACTURED_GOODS	0	1	1	1	
## DIPLOMATIC_EXCHANGE	0	1	1	1	
##					
## , , EGYPT					
##					
##	ALGERIA	ARGENTINA	BRAZIL	CHINA	CZECHOSLOVAKIA
## MINERALS	1	0	0	1	0
## CRUDE_MATERIALS	0	0	1	1	1

## FOODS	0	1	1	1	1
## MANUFACTURED_GOODS	0	0	1	1	1
## DIPLOMATIC_EXCHANGE	0	1	1	1	1
##	ECUADOR	EGYPT	ETHIOPIA	FINLAND	HONDURAS
## MINERALS	0	0	0	0	0
## CRUDE_MATERIALS	0	0	1	1	0
## FOODS	0	0	0	1	1
## MANUFACTURED_GOODS	0	0	0	1	0
## DIPLOMATIC_EXCHANGE	1	0	1	1	0
##	INDONESIA	ISRAEL	JAPAN	LIBERIA	MADAGASCAR
## MINERALS	0	1	1	1	0
## CRUDE_MATERIALS	0	0	1	1	0
## FOODS	1	1	1	0	0
## MANUFACTURED_GOODS	1	0	1	0	0
## DIPLOMATIC_EXCHANGE	1	1	1	1	0
##	NEW_ZEALAND	PAKISTAN	SPAIN	SWITZERLAND	SYRIA
## MINERALS	0	0	1	0	0
## CRUDE_MATERIALS	1	0	1	1	0
## FOODS	1	0	1	1	1
## MANUFACTURED_GOODS	1	0	1	1	0
## DIPLOMATIC_EXCHANGE	0	1	1	1	0
##	THAILAND	UNITED_KINGDOM	UNITED_STATES	YUGOSLAVIA	
## MINERALS	0	1	1	1	0
## CRUDE_MATERIALS	1	1	1	1	1
## FOODS	1	1	1	1	1
## MANUFACTURED_GOODS	0	1	1	1	1
## DIPLOMATIC_EXCHANGE	1	1	1	1	1
##					
## , , ETHIOPIA					
##					
##	ALGERIA	ARGENTINA	BRAZIL	CHINA	CZECHOSLOVAKIA
## MINERALS	0	0	0	0	0
## CRUDE_MATERIALS	0	0	0	1	0
## FOODS	0	0	0	0	0
## MANUFACTURED_GOODS	0	0	0	1	1
## DIPLOMATIC_EXCHANGE	1	1	0	1	1
##	ECUADOR	EGYPT	ETHIOPIA	FINLAND	HONDURAS
## MINERALS	0	0	0	0	0
## CRUDE_MATERIALS	0	0	0	0	0
## FOODS	0	0	0	0	0
## MANUFACTURED_GOODS	0	1	0	1	0
## DIPLOMATIC_EXCHANGE	0	1	0	1	0
##	INDONESIA	ISRAEL	JAPAN	LIBERIA	MADAGASCAR
## MINERALS	0	0	0	0	0
## CRUDE_MATERIALS	0	0	1	0	0
## FOODS	0	0	0	0	0
## MANUFACTURED_GOODS	0	1	1	0	0
## DIPLOMATIC_EXCHANGE	1	0	1	1	0
##	NEW_ZEALAND	PAKISTAN	SPAIN	SWITZERLAND	SYRIA
## MINERALS	0	0	0	0	0
## CRUDE_MATERIALS	0	0	0	0	0
## FOODS	0	0	0	1	0
## MANUFACTURED_GOODS	0	0	0	1	0
## DIPLOMATIC_EXCHANGE	0	0	1	1	0

##	THAILAND	UNITED_KINGDOM	UNITED_STATES	YUGOSLAVIA	
## MINERALS	0	1	1	0	
## CRUDE_MATERIALS	0	1	1	1	
## FOODS	0	1	1	0	
## MANUFACTURED_GOODS	0	1	1	1	
## DIPLOMATIC_EXCHANGE	0	1	1	1	
##					
## , , FINLAND					
##	ALGERIA	ARGENTINA	BRAZIL	CHINA	CZECHOSLOVAKIA
## MINERALS	0	0	0	1	0
## CRUDE_MATERIALS	1	1	1	1	1
## FOODS	0	1	1	1	1
## MANUFACTURED_GOODS	0	1	1	1	1
## DIPLOMATIC_EXCHANGE	0	1	1	1	1
##	ECUADOR	EGYPT	ETHIOPIA	FINLAND	HONDURAS
## MINERALS	0	0	0	0	0
## CRUDE_MATERIALS	1	1	0	0	0
## FOODS	1	1	1	0	1
## MANUFACTURED_GOODS	0	1	0	0	0
## DIPLOMATIC_EXCHANGE	0	1	0	0	0
##	INDONESIA	ISRAEL	JAPAN	LIBERIA	MADAGASCAR
## MINERALS	0	0	0	0	0
## CRUDE_MATERIALS	1	1	1	0	0
## FOODS	1	1	1	0	1
## MANUFACTURED_GOODS	1	1	1	0	0
## DIPLOMATIC_EXCHANGE	1	1	1	0	0
##	NEW_ZEALAND	PAKISTAN	SPAIN	SWITZERLAND	SYRIA
## MINERALS	0	0	1	0	0
## CRUDE_MATERIALS	1	0	1	1	0
## FOODS	1	1	1	1	0
## MANUFACTURED_GOODS	0	1	1	1	0
## DIPLOMATIC_EXCHANGE	0	0	1	1	0
##	THAILAND	UNITED_KINGDOM	UNITED_STATES	YUGOSLAVIA	
## MINERALS	0	1	1	0	
## CRUDE_MATERIALS	1	1	1	0	
## FOODS	1	1	1	1	
## MANUFACTURED_GOODS	1	1	1	1	
## DIPLOMATIC_EXCHANGE	0	1	1	1	
##					
## , , HONDURAS					
##	ALGERIA	ARGENTINA	BRAZIL	CHINA	CZECHOSLOVAKIA
## MINERALS	0	0	0	0	0
## CRUDE_MATERIALS	0	0	0	0	0
## FOODS	0	0	0	0	0
## MANUFACTURED_GOODS	0	0	1	1	1
## DIPLOMATIC_EXCHANGE	0	1	1	1	0
##	ECUADOR	EGYPT	ETHIOPIA	FINLAND	HONDURAS
## MINERALS	0	0	0	0	0
## CRUDE_MATERIALS	0	0	0	0	0
## FOODS	0	0	0	0	0
## MANUFACTURED_GOODS	0	0	0	1	0
## DIPLOMATIC_EXCHANGE	1	0	0	0	0

```

##          INDONESIA  ISRAEL  JAPAN  LIBERIA  MADAGASCAR
## MINERALS          0      0      1      0      0
## CRUDE_MATERIALS    0      0      0      0      0
## FOODS              0      0      1      0      0
## MANUFACTURED_GOODS 0      0      1      0      0
## DIPLOMATIC_EXCHANGE 0      1      1      0      0
##          NEW_ZEALAND  PAKISTAN  SPAIN  SWITZERLAND  SYRIA
## MINERALS          0      0      0      0      0
## CRUDE_MATERIALS    0      0      1      0      0
## FOODS              1      0      1      0      0
## MANUFACTURED_GOODS 0      0      1      1      0
## DIPLOMATIC_EXCHANGE 0      0      1      0      0
##          THAILAND  UNITED_KINGDOM  UNITED_STATES  YUGOSLAVIA
## MINERALS          0      0      1      0
## CRUDE_MATERIALS    0      0      1      0
## FOODS              0      1      1      0
## MANUFACTURED_GOODS 0      1      1      0
## DIPLOMATIC_EXCHANGE 0      1      1      0
##
## , , INDONESIA
##
##          ALGERIA  ARGENTINA  BRAZIL  CHINA  CZECHOSLOVAKIA
## MINERALS          0      0      0      1      0
## CRUDE_MATERIALS    1      1      1      1      0
## FOODS              0      1      1      1      0
## MANUFACTURED_GOODS 0      1      1      1      1
## DIPLOMATIC_EXCHANGE 1      1      1      0      1
##          ECUADOR  EGYPT  ETHIOPIA  FINLAND  HONDURAS
## MINERALS          0      0      0      0      0
## CRUDE_MATERIALS    0      1      0      1      0
## FOODS              0      1      0      1      0
## MANUFACTURED_GOODS 0      0      0      1      0
## DIPLOMATIC_EXCHANGE 0      1      0      1      0
##          INDONESIA  ISRAEL  JAPAN  LIBERIA  MADAGASCAR
## MINERALS          0      0      1      0      0
## CRUDE_MATERIALS    0      0      1      0      0
## FOODS              0      0      1      0      0
## MANUFACTURED_GOODS 0      0      1      0      0
## DIPLOMATIC_EXCHANGE 0      0      1      0      0
##          NEW_ZEALAND  PAKISTAN  SPAIN  SWITZERLAND  SYRIA
## MINERALS          0      0      0      1      0
## CRUDE_MATERIALS    1      1      1      1      0
## FOODS              1      1      1      1      0
## MANUFACTURED_GOODS 1      1      1      1      0
## DIPLOMATIC_EXCHANGE 1      1      1      1      1
##          THAILAND  UNITED_KINGDOM  UNITED_STATES  YUGOSLAVIA
## MINERALS          0      1      1      0
## CRUDE_MATERIALS    1      1      1      0
## FOODS              1      1      1      0
## MANUFACTURED_GOODS 1      1      1      1
## DIPLOMATIC_EXCHANGE 1      1      1      1
##
## , , ISRAEL
##

```

##	ALGERIA	ARGENTINA	BRAZIL	CHINA	CZECHOSLOVAKIA
## MINERALS	0	0	0	0	0
## CRUDE_MATERIALS	0	1	1	0	0
## FOODS	0	1	1	0	0
## MANUFACTURED_GOODS	0	1	1	0	0
## DIPLOMATIC_EXCHANGE	0	1	1	0	0
##	ECUADOR	EGYPT	ETHIOPIA	FINLAND	HONDURAS
## MINERALS	0	0	0	1	0
## CRUDE_MATERIALS	0	1	1	1	0
## FOODS	0	1	1	1	1
## MANUFACTURED_GOODS	0	0	0	1	0
## DIPLOMATIC_EXCHANGE	1	0	0	1	0
##	INDONESIA	ISRAEL	JAPAN	LIBERIA	MADAGASCAR
## MINERALS	0	0	0	0	0
## CRUDE_MATERIALS	0	0	1	1	0
## FOODS	0	0	1	0	0
## MANUFACTURED_GOODS	0	0	1	0	0
## DIPLOMATIC_EXCHANGE	0	0	1	0	0
##	NEW_ZEALAND	PAKISTAN	SPAIN	SWITZERLAND	SYRIA
## MINERALS	0	0	0	1	0
## CRUDE_MATERIALS	1	0	1	1	0
## FOODS	0	0	1	1	0
## MANUFACTURED_GOODS	0	0	1	1	0
## DIPLOMATIC_EXCHANGE	0	0	0	1	0
##	THAILAND	UNITED_KINGDOM	UNITED_STATES	YUGOSLAVIA	
## MINERALS	0	1	1	1	1
## CRUDE_MATERIALS	1	1	1	1	1
## FOODS	1	1	1	1	1
## MANUFACTURED_GOODS	1	1	1	1	1
## DIPLOMATIC_EXCHANGE	0	1	1	1	0
##					
## , , JAPAN					
##					
##	ALGERIA	ARGENTINA	BRAZIL	CHINA	CZECHOSLOVAKIA
## MINERALS	1	0	0	1	0
## CRUDE_MATERIALS	0	1	1	1	0
## FOODS	0	1	1	1	1
## MANUFACTURED_GOODS	1	1	1	1	1
## DIPLOMATIC_EXCHANGE	1	1	1	1	1
##	ECUADOR	EGYPT	ETHIOPIA	FINLAND	HONDURAS
## MINERALS	0	1	0	0	0
## CRUDE_MATERIALS	0	1	1	1	1
## FOODS	1	0	1	1	1
## MANUFACTURED_GOODS	0	1	0	1	0
## DIPLOMATIC_EXCHANGE	1	1	1	1	1
##	INDONESIA	ISRAEL	JAPAN	LIBERIA	MADAGASCAR
## MINERALS	1	0	0	0	0
## CRUDE_MATERIALS	1	0	0	1	1
## FOODS	1	1	0	0	1
## MANUFACTURED_GOODS	1	1	0	0	0
## DIPLOMATIC_EXCHANGE	1	1	0	1	1
##	NEW_ZEALAND	PAKISTAN	SPAIN	SWITZERLAND	SYRIA
## MINERALS	1	0	0	0	0
## CRUDE_MATERIALS	1	1	1	1	1

## FOODS	1	1	1	1	0
## MANUFACTURED_GOODS	1	1	1	1	0
## DIPLOMATIC_EXCHANGE	1	1	1	1	1
##	THAILAND	UNITED_KINGDOM	UNITED_STATES	YUGOSLAVIA	
## MINERALS	0	0	1	0	
## CRUDE_MATERIALS	1	1	1	1	
## FOODS	1	1	1	1	
## MANUFACTURED_GOODS	1	1	1	1	
## DIPLOMATIC_EXCHANGE	1	1	1	1	
##					
## , , LIBERIA					
##					
##	ALGERIA	ARGENTINA	BRAZIL	CHINA	CZECHOSLOVAKIA
## MINERALS	0	0	1	0	0
## CRUDE_MATERIALS	0	0	0	0	0
## FOODS	0	0	1	1	0
## MANUFACTURED_GOODS	0	0	1	1	1
## DIPLOMATIC_EXCHANGE	1	0	0	1	0
##	ECUADOR	EGYPT	ETHIOPIA	FINLAND	HONDURAS
## MINERALS	0	0	0	0	0
## CRUDE_MATERIALS	0	0	0	0	0
## FOODS	0	0	0	0	0
## MANUFACTURED_GOODS	0	0	0	0	0
## DIPLOMATIC_EXCHANGE	0	1	1	0	0
##	INDONESIA	ISRAEL	JAPAN	LIBERIA	MADAGASCAR
## MINERALS	0	0	0	0	0
## CRUDE_MATERIALS	0	0	0	0	0
## FOODS	0	0	1	0	0
## MANUFACTURED_GOODS	0	0	1	0	0
## DIPLOMATIC_EXCHANGE	0	1	1	0	0
##	NEW_ZEALAND	PAKISTAN	SPAIN	SWITZERLAND	SYRIA
## MINERALS	0	0	1	1	0
## CRUDE_MATERIALS	0	0	0	0	0
## FOODS	0	0	1	1	0
## MANUFACTURED_GOODS	0	1	1	1	0
## DIPLOMATIC_EXCHANGE	0	0	1	1	0
##	THAILAND	UNITED_KINGDOM	UNITED_STATES	YUGOSLAVIA	
## MINERALS	0	1	1	0	
## CRUDE_MATERIALS	0	1	1	1	
## FOODS	0	1	1	1	
## MANUFACTURED_GOODS	0	1	1	1	
## DIPLOMATIC_EXCHANGE	0	1	1	1	
##					
## , , MADAGASCAR					
##					
##	ALGERIA	ARGENTINA	BRAZIL	CHINA	CZECHOSLOVAKIA
## MINERALS	0	0	0	1	0
## CRUDE_MATERIALS	0	0	1	0	0
## FOODS	0	0	0	0	0
## MANUFACTURED_GOODS	0	0	0	1	0
## DIPLOMATIC_EXCHANGE	1	0	0	1	0
##	ECUADOR	EGYPT	ETHIOPIA	FINLAND	HONDURAS
## MINERALS	0	0	0	0	0
## CRUDE_MATERIALS	0	0	0	0	0

## FOODS	0	0	0	0	0
## MANUFACTURED_GOODS	0	0	0	0	0
## DIPLOMATIC_EXCHANGE	0	1	0	0	0
##	INDONESIA	ISRAEL	JAPAN	LIBERIA	MADAGASCAR
## MINERALS	0	0	0	0	0
## CRUDE_MATERIALS	0	0	0	0	0
## FOODS	0	0	1	0	0
## MANUFACTURED_GOODS	0	0	1	0	0
## DIPLOMATIC_EXCHANGE	1	0	1	0	0
##	NEW_ZEALAND	PAKISTAN	SPAIN	SWITZERLAND	SYRIA
## MINERALS	0		0	1	0
## CRUDE_MATERIALS	0		0	0	0
## FOODS	0		0	0	1
## MANUFACTURED_GOODS	0		0	1	1
## DIPLOMATIC_EXCHANGE	0		0	0	1
##	THAILAND	UNITED_KINGDOM		UNITED_STATES	YUGOSLAVIA
## MINERALS	1		0		1
## CRUDE_MATERIALS	0		0		1
## FOODS	1		1		1
## MANUFACTURED_GOODS	0		1		1
## DIPLOMATIC_EXCHANGE	0		1		1
##					
## , , NEW_ZEALAND					
##					
##	ALGERIA	ARGENTINA	BRAZIL	CHINA	CZECHOSLOVAKIA
## MINERALS	0		0	1	0
## CRUDE_MATERIALS	0		0	1	0
## FOODS	0	1	1	1	0
## MANUFACTURED_GOODS	0	0	1	1	1
## DIPLOMATIC_EXCHANGE	0	0	0	1	1
##	ECUADOR	EGYPT	ETHIOPIA	FINLAND	HONDURAS
## MINERALS	0	0	0	0	0
## CRUDE_MATERIALS	0	0	0	1	0
## FOODS	1	0	0	0	0
## MANUFACTURED_GOODS	0	0	0	1	0
## DIPLOMATIC_EXCHANGE	0	1	0	0	0
##	INDONESIA	ISRAEL	JAPAN	LIBERIA	MADAGASCAR
## MINERALS	1	0	1	0	0
## CRUDE_MATERIALS	1	0	1	0	0
## FOODS	1	1	1	0	0
## MANUFACTURED_GOODS	1	1	1	0	0
## DIPLOMATIC_EXCHANGE	1	1	1	0	0
##	NEW_ZEALAND	PAKISTAN	SPAIN	SWITZERLAND	SYRIA
## MINERALS	0		0		0
## CRUDE_MATERIALS	0		0	1	1
## FOODS	0		1	1	1
## MANUFACTURED_GOODS	0		1	1	1
## DIPLOMATIC_EXCHANGE	0		0	0	1
##	THAILAND	UNITED_KINGDOM		UNITED_STATES	YUGOSLAVIA
## MINERALS	0		1		1
## CRUDE_MATERIALS	1		1		1
## FOODS	1		1		1
## MANUFACTURED_GOODS	1		1		1
## DIPLOMATIC_EXCHANGE	1		1		1


```

##
## , , PAKISTAN
##
##          ALGERIA  ARGENTINA  BRAZIL  CHINA  CZECHOSLOVAKIA
## MINERALS          0          0          0          1          0
## CRUDE_MATERIALS    0          0          1          1          0
## FOODS              0          1          1          1          0
## MANUFACTURED_GOODS 0          1          1          1          1
## DIPLOMATIC_EXCHANGE 1          1          1          1          1
##
##          ECUADOR  EGYPT  ETHIOPIA  FINLAND  HONDURAS
## MINERALS          0          0          0          0          0
## CRUDE_MATERIALS    0          1          0          1          0
## FOODS              0          0          0          0          0
## MANUFACTURED_GOODS 0          0          0          1          0
## DIPLOMATIC_EXCHANGE 0          1          0          0          0
##
##          INDONESIA  ISRAEL  JAPAN  LIBERIA  MADAGASCAR
## MINERALS            0          0          1          0          0
## CRUDE_MATERIALS      1          0          1          1          0
## FOODS                1          0          1          1          0
## MANUFACTURED_GOODS   1          0          1          0          0
## DIPLOMATIC_EXCHANGE   1          0          1          0          0
##
##          NEW_ZEALAND  PAKISTAN  SPAIN  SWITZERLAND  SYRIA
## MINERALS            0          0          1          0          0
## CRUDE_MATERIALS      1          0          1          1          0
## FOODS                1          0          0          1          1
## MANUFACTURED_GOODS   1          0          1          1          0
## DIPLOMATIC_EXCHANGE   0          0          1          1          1
##
##          THAILAND  UNITED_KINGDOM  UNITED_STATES  YUGOSLAVIA
## MINERALS            0          1          1          1          0
## CRUDE_MATERIALS      1          1          1          1          1
## FOODS                1          1          1          1          0
## MANUFACTURED_GOODS   1          1          1          1          1
## DIPLOMATIC_EXCHANGE   1          1          1          1          1
##
## , , SPAIN
##
##          ALGERIA  ARGENTINA  BRAZIL  CHINA  CZECHOSLOVAKIA
## MINERALS          1          1          0          1          0
## CRUDE_MATERIALS    1          1          1          1          1
## FOODS              1          1          1          1          1
## MANUFACTURED_GOODS 0          1          1          1          1
## DIPLOMATIC_EXCHANGE 1          1          1          1          1
##
##          ECUADOR  EGYPT  ETHIOPIA  FINLAND  HONDURAS
## MINERALS          0          1          0          1          0
## CRUDE_MATERIALS    0          1          1          1          1
## FOODS              1          0          1          1          1
## MANUFACTURED_GOODS 0          1          1          1          0
## DIPLOMATIC_EXCHANGE 1          1          0          1          1
##
##          INDONESIA  ISRAEL  JAPAN  LIBERIA  MADAGASCAR
## MINERALS            1          0          1          0          0
## CRUDE_MATERIALS      1          1          1          1          1
## FOODS                1          1          1          1          1
## MANUFACTURED_GOODS   1          1          1          0          0
## DIPLOMATIC_EXCHANGE   1          0          1          0          0

```

```

##          NEW_ZEALAND  PAKISTAN  SPAIN  SWITZERLAND  SYRIA
## MINERALS                0        0        0            0        1
## CRUDE_MATERIALS        1        1        0            1        1
## FOODS                  1        0        0            1        0
## MANUFACTURED_GOODS    1        1        0            1        0
## DIPLOMATIC_EXCHANGE    0        1        0            1        1
##          THAILAND  UNITED_KINGDOM  UNITED_STATES  YUGOSLAVIA
## MINERALS                0            1            1            1
## CRUDE_MATERIALS        1            1            1            1
## FOODS                  1            1            1            1
## MANUFACTURED_GOODS    1            1            1            1
## DIPLOMATIC_EXCHANGE    1            1            1            1
##
## , , SWITZERLAND
##
##          ALGERIA  ARGENTINA  BRAZIL  CHINA  CZECHOSLOVAKIA
## MINERALS                1            0        0        0            1
## CRUDE_MATERIALS        0            1        1        1            1
## FOODS                  0            1        1        1            1
## MANUFACTURED_GOODS    0            1        1        1            1
## DIPLOMATIC_EXCHANGE    1            1        1        1            1
##          ECUADOR  EGYPT  ETHIOPIA  FINLAND  HONDURAS
## MINERALS                0        0            0        0            0
## CRUDE_MATERIALS        0        1            1        1            1
## FOODS                  1        1            1        1            1
## MANUFACTURED_GOODS    0        1            0        1            0
## DIPLOMATIC_EXCHANGE    1        1            0        1            0
##          INDONESIA  ISRAEL  JAPAN  LIBERIA  MADAGASCAR
## MINERALS                0            0        0        0            0
## CRUDE_MATERIALS        1            1        1        1            0
## FOODS                  1            1        1        0            1
## MANUFACTURED_GOODS    1            1        1        0            0
## DIPLOMATIC_EXCHANGE    1            1        1        0            0
##          NEW_ZEALAND  PAKISTAN  SPAIN  SWITZERLAND  SYRIA
## MINERALS                0            0        0            0            0
## CRUDE_MATERIALS        1            1        1            0            0
## FOODS                  1            1        1            0            0
## MANUFACTURED_GOODS    0            1        1            0            0
## DIPLOMATIC_EXCHANGE    0            1        1            0            0
##          THAILAND  UNITED_KINGDOM  UNITED_STATES  YUGOSLAVIA
## MINERALS                0            1            1            1
## CRUDE_MATERIALS        1            1            1            1
## FOODS                  1            1            1            1
## MANUFACTURED_GOODS    1            1            1            1
## DIPLOMATIC_EXCHANGE    1            1            1            1
##
## , , SYRIA
##
##          ALGERIA  ARGENTINA  BRAZIL  CHINA  CZECHOSLOVAKIA
## MINERALS                1            0        0        0            0
## CRUDE_MATERIALS        0            0        0        0            1
## FOODS                  0            1        1        1            1
## MANUFACTURED_GOODS    0            0        1        1            1
## DIPLOMATIC_EXCHANGE    1            1        1        1            1

```

```

##          ECUADOR  EGYPT  ETHIOPIA  FINLAND  HONDURAS
## MINERALS          0      0          0          0          0
## CRUDE_MATERIALS    0      0          1          0          0
## FOODS              0      0          0          1          1
## MANUFACTURED_GOODS 0      0          0          1          0
## DIPLOMATIC_EXCHANGE 0      0          0          0          0
##          INDONESIA  ISRAEL   JAPAN   LIBERIA  MADAGASCAR
## MINERALS          0      0          0          0          0
## CRUDE_MATERIALS    0      0          1          1          0
## FOODS              0      0          1          0          0
## MANUFACTURED_GOODS 0      0          1          0          0
## DIPLOMATIC_EXCHANGE 1      0          1          0          0
##          NEW_ZEALAND  PAKISTAN  SPAIN   SWITZERLAND  SYRIA
## MINERALS          0          0          1          0          0
## CRUDE_MATERIALS    1          0          1          1          0
## FOODS              1          0          1          1          0
## MANUFACTURED_GOODS 0          1          1          1          0
## DIPLOMATIC_EXCHANGE 0          1          1          1          0
##          THAILAND  UNITED_KINGDOM  UNITED_STATES  YUGOSLAVIA
## MINERALS          0          1          1          1          1
## CRUDE_MATERIALS    0          1          1          1          1
## FOODS              1          1          1          1          1
## MANUFACTURED_GOODS 1          1          1          1          1
## DIPLOMATIC_EXCHANGE 0          1          1          1          1
##
## , , THAILAND
##
##          ALGERIA  ARGENTINA  BRAZIL  CHINA  CZECHOSLOVAKIA
## MINERALS          0          0          0          1          0
## CRUDE_MATERIALS    0          1          1          1          0
## FOODS              0          1          1          1          1
## MANUFACTURED_GOODS 0          1          1          1          1
## DIPLOMATIC_EXCHANGE 0          1          1          1          0
##          ECUADOR  EGYPT  ETHIOPIA  FINLAND  HONDURAS
## MINERALS          0      0          0          0          0
## CRUDE_MATERIALS    0      1          0          1          0
## FOODS              0      0          0          1          0
## MANUFACTURED_GOODS 0      0          0          1          0
## DIPLOMATIC_EXCHANGE 0      1          0          1          0
##          INDONESIA  ISRAEL   JAPAN   LIBERIA  MADAGASCAR
## MINERALS          1      0          1          0          0
## CRUDE_MATERIALS    1      0          1          0          0
## FOODS              1      1          1          0          0
## MANUFACTURED_GOODS 1      1          1          0          0
## DIPLOMATIC_EXCHANGE 1      1          1          0          0
##          NEW_ZEALAND  PAKISTAN  SPAIN   SWITZERLAND  SYRIA
## MINERALS          0          1          0          0          0
## CRUDE_MATERIALS    1          1          1          1          0
## FOODS              1          0          1          1          0
## MANUFACTURED_GOODS 1          1          1          1          0
## DIPLOMATIC_EXCHANGE 1          1          1          1          0
##          THAILAND  UNITED_KINGDOM  UNITED_STATES  YUGOSLAVIA
## MINERALS          0          1          1          1          0
## CRUDE_MATERIALS    0          1          1          1          1

```

## FOODS	0		1		1	0
## MANUFACTURED_GOODS	0		1		1	1
## DIPLOMATIC_EXCHANGE	0		1		1	1
##						
## , , UNITED_KINGDOM						
##						
	ALGERIA	ARGENTINA	BRAZIL	CHINA	CZECHOSLOVAKIA	
## MINERALS	1	0	1	0		0
## CRUDE_MATERIALS	0	0	1	1		1
## FOODS	0	0	1	1		1
## MANUFACTURED_GOODS	0	0	1	1		1
## DIPLOMATIC_EXCHANGE	1	0	1	1		1
##	ECUADOR	EGYPT	ETHIOPIA	FINLAND	HONDURAS	
## MINERALS	0	1	0	1		0
## CRUDE_MATERIALS	1	1	1	1		1
## FOODS	1	1	1	1		1
## MANUFACTURED_GOODS	0	1	1	1		0
## DIPLOMATIC_EXCHANGE	1	1	1	1		1
##	INDONESIA	ISRAEL	JAPAN	LIBERIA	MADAGASCAR	
## MINERALS	1	0	1	0		0
## CRUDE_MATERIALS	1	1	1	1		1
## FOODS	1	1	1	0		0
## MANUFACTURED_GOODS	1	1	1	0		1
## DIPLOMATIC_EXCHANGE	1	1	1	1		0
##	NEW_ZEALAND	PAKISTAN	SPAIN	SWITZERLAND	SYRIA	
## MINERALS		0	0	1		1
## CRUDE_MATERIALS		1	1	1		1
## FOODS		1	1	1		0
## MANUFACTURED_GOODS		1	1	1		0
## DIPLOMATIC_EXCHANGE		1	1	1		1
##	THAILAND	UNITED_KINGDOM	UNITED_STATES	YUGOSLAVIA		
## MINERALS	0		0		1	0
## CRUDE_MATERIALS	1		0		1	1
## FOODS	1		0		1	1
## MANUFACTURED_GOODS	1		0		1	1
## DIPLOMATIC_EXCHANGE	1		0		1	1
##						
## , , UNITED_STATES						
##						
	ALGERIA	ARGENTINA	BRAZIL	CHINA	CZECHOSLOVAKIA	
## MINERALS	1	1	1	1		0
## CRUDE_MATERIALS	0	1	1	1		0
## FOODS	0	1	1	1		1
## MANUFACTURED_GOODS	0	1	1	1		1
## DIPLOMATIC_EXCHANGE	1	1	1	1		1
##	ECUADOR	EGYPT	ETHIOPIA	FINLAND	HONDURAS	
## MINERALS	1	1	0	1		0
## CRUDE_MATERIALS	1	1	1	1		1
## FOODS	1	1	1	1		1
## MANUFACTURED_GOODS	1	1	0	1		1
## DIPLOMATIC_EXCHANGE	1	1	1	1		1
##	INDONESIA	ISRAEL	JAPAN	LIBERIA	MADAGASCAR	
## MINERALS	1	0	1	0		0
## CRUDE_MATERIALS	1	1	1	1		1

```

## FOODS                      1          1          1          1          1
## MANUFACTURED_GOODS        1          1          1          0          0
## DIPLOMATIC_EXCHANGE       1          1          1          1          1
##
## NEW_ZEALAND  PAKISTAN  SPAIN  SWITZERLAND  SYRIA
## MINERALS                      0          0          1          0          0
## CRUDE_MATERIALS              1          1          1          1          0
## FOODS                       1          1          1          1          0
## MANUFACTURED_GOODS          1          1          1          1          0
## DIPLOMATIC_EXCHANGE         1          1          1          1          1
##
## THAILAND  UNITED_KINGDOM  UNITED_STATES  YUGOSLAVIA
## MINERALS              1          1          0          1
## CRUDE_MATERIALS        1          1          0          1
## FOODS                  1          1          0          1
## MANUFACTURED_GOODS     1          1          0          1
## DIPLOMATIC_EXCHANGE     1          1          0          1
##
## , , YUGOSLAVIA
##
## ALGERIA  ARGENTINA  BRAZIL  CHINA  CZECHOSLOVAKIA
## MINERALS              1          0          0          0          1
## CRUDE_MATERIALS        1          1          1          1          1
## FOODS                  0          1          1          0          1
## MANUFACTURED_GOODS     1          0          1          1          1
## DIPLOMATIC_EXCHANGE     1          1          1          1          1
##
## ECUADOR  EGYPT  ETHIOPIA  FINLAND  HONDURAS
## MINERALS              0          1          0          0          0
## CRUDE_MATERIALS        0          1          0          1          1
## FOODS                  1          0          0          1          1
## MANUFACTURED_GOODS     0          1          0          1          0
## DIPLOMATIC_EXCHANGE     1          1          1          1          0
##
## INDONESIA  ISRAEL  JAPAN  LIBERIA  MADAGASCAR
## MINERALS              0          0          0          1          0
## CRUDE_MATERIALS        1          1          1          1          0
## FOODS                  1          1          0          0          0
## MANUFACTURED_GOODS     1          1          1          0          0
## DIPLOMATIC_EXCHANGE     1          0          1          0          0
##
## NEW_ZEALAND  PAKISTAN  SPAIN  SWITZERLAND  SYRIA
## MINERALS                      0          0          1          1          0
## CRUDE_MATERIALS              1          0          1          1          1
## FOODS                       0          0          1          1          0
## MANUFACTURED_GOODS          1          0          1          1          0
## DIPLOMATIC_EXCHANGE         0          1          1          1          1
##
## THAILAND  UNITED_KINGDOM  UNITED_STATES  YUGOSLAVIA
## MINERALS              0          1          1          0
## CRUDE_MATERIALS        1          1          1          0
## FOODS                  0          1          1          0
## MANUFACTURED_GOODS     1          1          1          0
## DIPLOMATIC_EXCHANGE     1          1          1          0

```

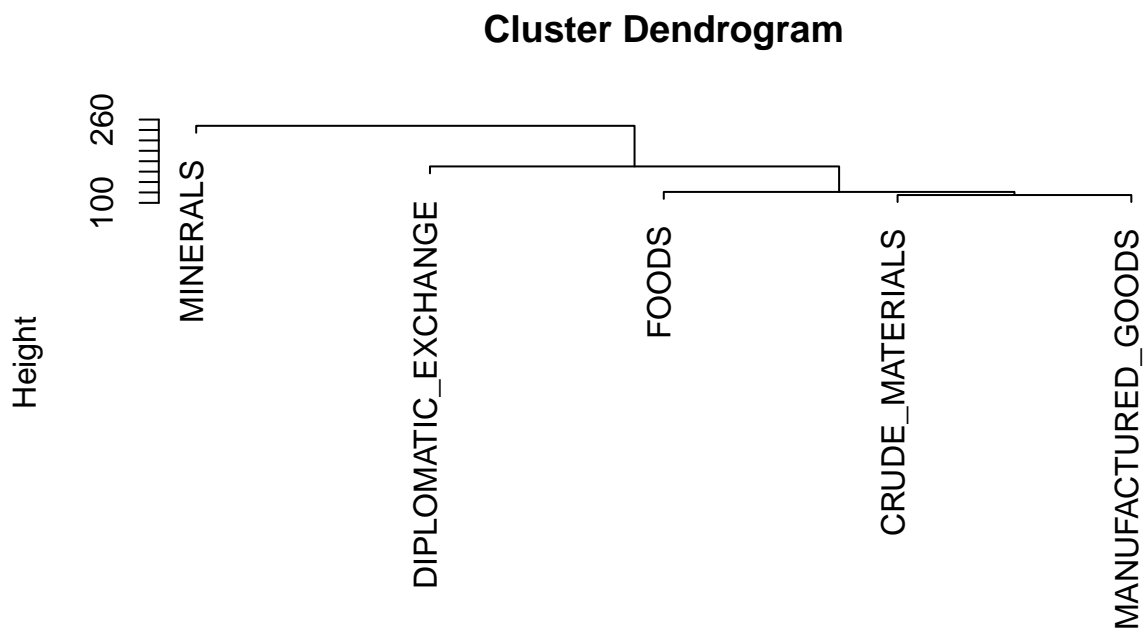
(a) Clustering

Show a hierarchical clustering of the trade networks, based on the Hamming distance. Compare this with a two-dimensional MDS solution on the same data.

```
#Clustering
trade_dist <- hdist(trade)
trade_dist
```

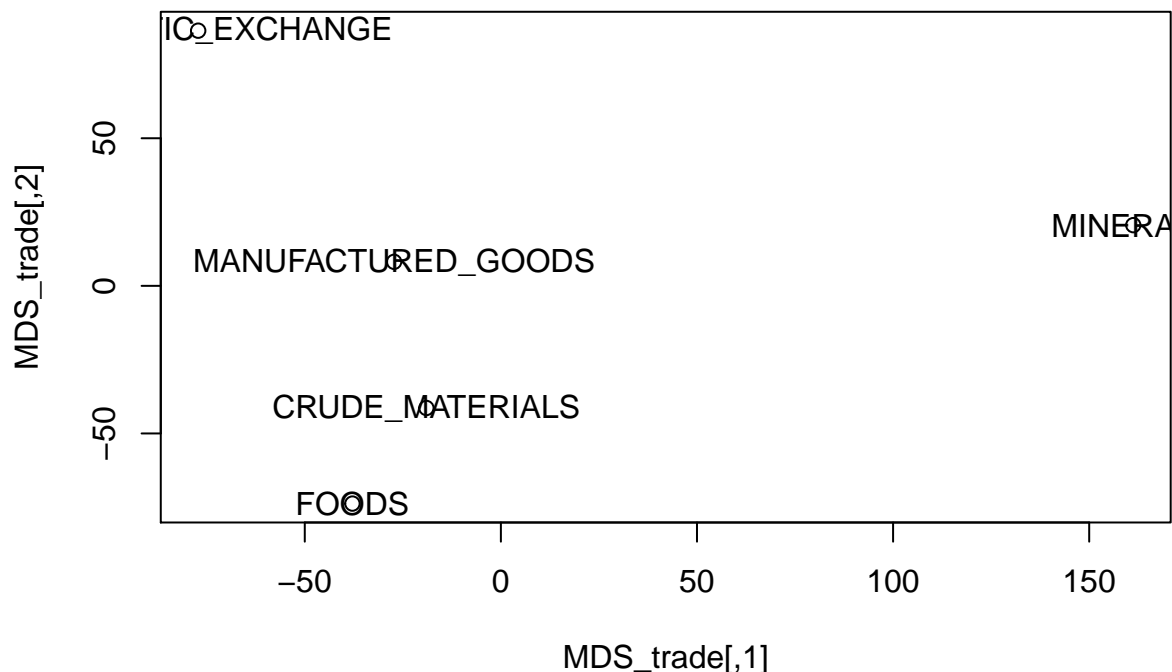
```
##      1    2    3    4    5
## 1    0  204  224  201  248
## 2  204    0  118  115  158
## 3  224  118    0  121  170
## 4  201  115  121    0  127
## 5  248  158  170  127    0
```

```
clus_trade <- hclust(as.dist(trade_dist))
plot(clus_trade, labels=rownames(trade))
```



```
as.dist(trade_dist)
hclust (*, "complete")
```

```
# MDS Solution
MDS_trade <- cmdscale(trade_dist)
plot(MDS_trade)
text(MDS_trade, label=rownames(trade))
```



The cluster analysis performed on the trade graph based on hamming distance, shows that there are three clusters. Clustering is seen between Crude_materials and Manufactured_goods. The other clusters are the separate Foods, Diplomatic_Exchange and Minerals cluster. This may imply that there may be some similarity in terms of the trade relation between countries which trade Crude_materials and Manufactured_goods.

From the plot of MDS, we can again note that Crude-Materials and manufactured goods are proximate to each other, which may imply similar patterns in their trade relations. One more important point which can be noted from the plot is that Crude_materials and foods are closest to each other. This implies that they have a stronger similar trade pattern as compared to that between Crude_materials and Manufactured_goods.

(b) PCA

Conduct a PCA on the trade networks. How many dimensions are needed to account for the bulk of the variation in these networks? Try using a scree plot to help with this question. Plot the loadings on the first two components; what does this suggest about the underlying relationships among the trade networks?

```
#graph correlation matrix
```

```
trade_cor <- gcor(trade)
```

```
trade_cor
```

```
##           1           2           3           4           5
## 1 1.0000000 0.3725626 0.2877321 0.3922966 0.3380220
## 2 0.3725626 1.0000000 0.5670013 0.5775224 0.4165298
## 3 0.2877321 0.5670013 1.0000000 0.5554769 0.3700570
## 4 0.3922966 0.5775224 0.5554769 1.0000000 0.5333617
## 5 0.3380220 0.4165298 0.3700570 0.5333617 1.0000000
```

```
#Eigen decomposition
```

```
trade_eig <- eigen(trade_cor)
```

```
#Eigen Values extraction
```

```
evals <- trade_eig$value
```

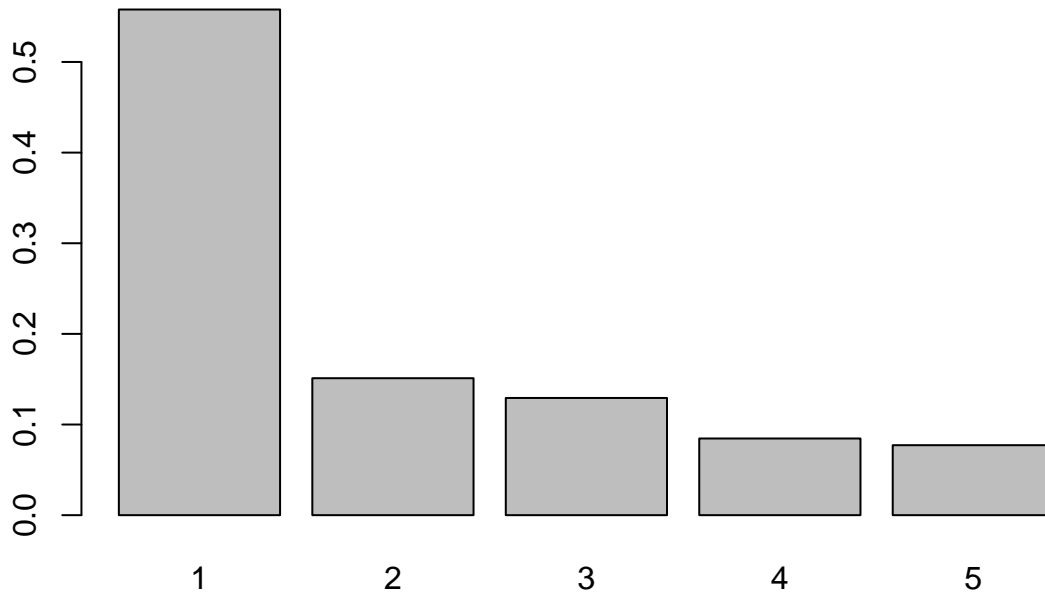
```
#Calculate variance.
```

```
evals/sum(evals)
```

```
## [1] 0.55785530 0.15109490 0.12929625 0.08457135 0.07718221
```

```
#Screenplot
```

```
barplot(evals/sum(evals),names.arg=1:length(evals))
```



```
#Load 3 components
```

```
load<-trade_eig$vector[,1:3]
```

```
rownames(load)<-rownames(trade)
```

```
load
```

```
##           [,1]      [,2]      [,3]
## MINERALS   -0.3630871  0.8347337  0.3871989
## CRUDE_MATERIALS -0.4801280 -0.2271629  0.2725159
## FOODS      -0.4540009 -0.4629607  0.3095938
## MANUFACTURED_GOODS -0.5018676 -0.1047656 -0.1336908
## DIPLOMATIC_EXCHANGE -0.4238597  0.1621982 -0.8136895
```

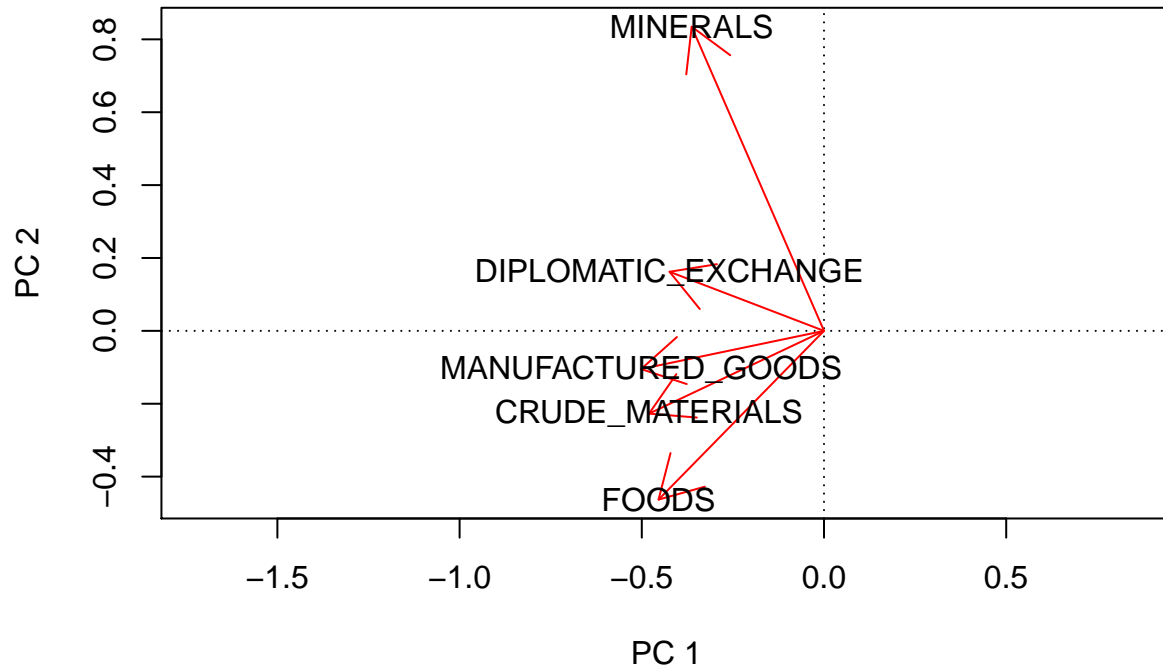
```
#Plot 2 components
```

```
plot(load[,1:2],type="n",asp=1,xlab="PC 1",ylab="PC 2")
```

```
abline(h=0,v=0,lty=3)
```

```
arrows(0,0,load[,1],load[,2],col=2) # Should be read angularly!
```

```
text(load[,1:2],label=rownames(trade[,0,0]))
```

The scree plot is a reflection of how much each component (here it is 5), contribute to the variance in the data set. From the plot, it can be seen that the first component accounts to about 65-70% variance, second component accounts to about 15% variance and 3rd accounts to about 12-13% variance. So we can say that the first 3 components collectively describe more than 90% variance in data. Thus PCA, helps us to reduce the number of principle components and analyze the dataset using 3 components. From the plot of loadings, we can see how minerals pertains to the highest variance in the dataset as it is directed away from the other features. The next highest accounted variance is for crude_materials which is orthogonal to minerals thus verifying the process of PCA.

(c) Discussion

Compare your PCA results to those obtained using MDS. In what ways are they similar? Different? In the MDS plot, Mineral is seen to be the farthest away from other graphs implying that there is not much similarity in graph patterns as compared to the other graphs. The same result can be seen from PCA, as the graph for minerals shows the highest variance in the dataset.

Similar: From the MDS plot for Manufactured_goods, crude_materials and foods we can see that there is similarity in their graph patterns as they are proximate to each other on the euclidean space. From the PCA plot, Manufactured_goods, crude_materials and foods seem to be in the same direction which implies lesser variance in their graph patterns. Thus the PCA and MDS solution point towards the same conclusion.

Different: From the MDS plot, it seems that there is more similarity between Crude_materials and Food, as compared to that between Manufactured_goods and crude_materials. But the PCA plot is indicative of more similarity between foods and crude_materials as compared to crude_materials and manufactured_goods.