Package 'ITNr'

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Type Package

Title Analysis of the International Trade Network

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Description Functions to clean and process international trade data into an international trade network (ITN) are provided. It then provides a set a functions to undertake analysis and plots of the ITN (extract the backbone, centrality, blockmodels, clustering). Examining the key players in the ITN and regional trade patterns.

Depends R (>= 2.15.1), network

License GPL-3

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Imports stats,circlize,graphics,RColorBrewer,xergm.common, reshape2,maps,blockmodeling,igraph,utils,dplyr,plyr, cowplot,ggplot2,GGally,fastmatch,intergraph, sna,tnet,WDI,networkDynamic

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Contents

`abs_diff_mat` *abs_diff_mat*

Description

This takes a dataframe of node attributes and convert one into a absolute difference matrix

Usage

```
abs_diff_mat(DF, attrname)
```

Arguments

`DF`	Dataframe of node attribute
`attrname`	names of the attribute from the dataframe to create the matrix for.

Value

Absolute difference matrix

`cap_lat_lon` *cap_lat_lon*

Description

Dataframe of capital city latitude and longitude coordinates

Usage

```
cap_lat_lon
```

`Comtradrclean` *Comtradr data clean*

Description

This function takes (import) trade data downloaded from comtrade - potentially using the comtradr package, cleans it and transforms it into a network. Adding a number of country level attributes to nodes in the network, including: regional partition, GDP, GDP per capita, GDP growth and FDI. However, it is important to note the limits of using comtradr to construct a network. Firstly when downloading the data with comtradr, you must specify reporters and partners – yet you cannot put "all" for both – only for either reporters or partners. Then for the other you are limited to a character vector of country names, length five or fewer. Therefore, this will not give you a full network. However, this function can be applied to trade data downloaded from UN Comtrade (download csv and read into R as a dataframe), or any other trade data. You just make sure it has the following column names: reporter_iso, partner_iso, trade_value_usd and year. Some dataformats may have different names. Also - it is important to note that this function is for import data.

Usage

```
Comtradrclean(DF, YEAR, threshold, cutoff)
```

Arguments

`DF`	Dataframe of trade data downloaded (potentially using the comtradr package)
`YEAR`	Year
`threshold`	Apply a threshold - TRUE, Extract the backbone - FALSE
`cutoff`	Threshold - cutoff level, Backbone - significance level

Value

International Trade Network - igraph object

core_periphery_weighted *Core-Periphery for Weighted Networks*

Description

This function implements rich club core-periphery algorithm (Ma & Mondragón, 2015) to identify members of the core and periphery in weighted networks

Usage

```
core_periphery_weighted(gs, type)
```

Arguments

gs	International Trade Network - igraph object. Note for networks not produced using ITNr there needs to be a vertex attribute "name" and edge attribute "weight"
type	directed/undirected

Value

List - 1.)igraph object with core-periphery results added as a node attribute. 2.) Dataframe of core-periphery results.

References

Ma A, Mondragón RJ (2015) Rich-Cores in Networks. PLoS ONE 10(3): e0119678. https://doi.org/10.1371/journal.pone.011

Examples

```
require(igraph)
##Create random International Trade Network (igraph object)
ITN<-erdos.renyi.game(50,0.05,directed = TRUE)

##Add edge weights
E(ITN)$weight<-runif(ecount(ITN), 0, 1)

##Add vertex names
V(ITN)$name<-1:vcount(ITN)

##Implement core-periphery algorithm
ITNcp<-core_periphery_weighted(ITN,"directed")
```

ei_group *Group level E-I Index*

Description

This function calculates the E-I Index (External-internal) at the group/attribute level

Usage

```
ei_group(gs, attrname)
```

Arguments

gs	igraph object
attrname	Attribute name

Value

Group level results dataframe

Examples

```
require(igraph)
##Create random network (igraph object)
gs<-erdos.renyi.game(75,0.05,directed = TRUE)

##Add vertex names
V(gs)$name<-1:vcount(gs)

## Add an attribute
V(gs)$letters<- rep(LETTERS[1:5],15)

##Calculate the Group E-I Results
EI_GROUP_DATAFRAME<-ei_group(gs,"letters")
```

ei_ind *Individual/Node level E-I Index*

Description

This function calculates the E-I Index (External-internal) at the individual/node level

Usage

```
ei_ind(gs, attrname)
```

Arguments

gs	igraph object
attrname	Attribute name

Value

Group level results dataframe

Examples

```
require(igraph)
##Create random network (igraph object)
gs<-erdos.renyi.game(30,0.05,directed = TRUE)

##Add vertex names
V(gs)$name<-1:vcount(gs)

## Add an attribute
V(gs)$letters<- rep(LETTERS[1:5],6)

##Calculate the Individual E-I Results
EI_IND_DATAFRAME<-ei_ind(gs,"letters")
```

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ei_network *Network level E-I Index*

Description

This function calculates the E-I Index (External-internal) at the network level

Usage

```
ei_network(gs, attrname)
```

Arguments

gs	igraph object
attrname	Attribute name

Value

Group level results dataframe

Examples

```
require(igraph)
##Create random network (igraph object)
gs<-erdos.renyi.game(75,0.05,directed = TRUE)

##Add vertex names
V(gs)$name<-1:vcount(gs)

## Add an attribute
V(gs)$letters<- rep(LETTERS[1:5],15)

##Calculate the Group E-I Results
EI_NETWORK<-ei_network(gs,"letters")
```

ELEnet16 *Electrical Automotive Goods 2016 Network*

Description

Electrical Automotive Goods 2016 Network. Electrical automotive goods category as defined by Amighini & Gogoni (2014)

Usage

```
ELEnet16
```

References

Amighini, A. and Gorgoni, S. (2014) The International Reorganisation of Auto Production, The World Economy, 37(7), pp. 923–952.

ELEnetList *List of Electrical Automotive Goods Networks (2006-2016)*

Description

List of Electrical Automotive Goods Networks for 2006 - 2016. Electrical automotive goods category as defined by Amighini & Gogoni (2014)

Usage

```
ELEnetList
```

References

Amighini, A. and Gorgoni, S. (2014) The International Reorganisation of Auto Production, The World Economy, 37(7), pp. 923–952. (list of igraph objects)

get.backbone *get.backbone*

Description

This function extracts the backbone of a network

Usage

```
get.backbone(G, alpha, directed = TRUE)
```

Arguments

G	igraph network
alpha	Significance level
directed	Default is TRUE

Value

Backbone of the network

References

Serrano, M. Á., Boguñá, M. and Vespignani, A. (2009) Extracting the multiscale backbone of complex weighted networks, Proceedings of the National Academy of Sciences, 106(16), pp. 6483–6488.

Examples

```
require(igraph)

##Create a random (directed) network
gs<-erdos.renyi.game(50,0.2,directed = TRUE)

##Add edge weights to the network
E(gs)$weight<-runif(ecount(gs), 0, 1)

##Extract backbone at 0.05 significance level
backbone<-get.backbone(gs,0.1)
```

`isEmpty` *isEmpty*

Description

This function check whether data is numeric(0) and give returns an NA if this is true and the value of the data otherwise.

Usage

```
isEmpty(x)
```

Arguments

`x`	Data

Value

NA or the data

`ITNadjust` *Adjust ITN*

Description

This function adjusts ITN matrices so they are the same size

Usage

```
ITNadjust(MATlist, j)
```

Arguments

`MATlist`	A list of ITN matrices
`j`	Element of matrix list to compare with others

Value

Matrix

Examples

```
##Create a list of random matrices (of different sizes)
##Labels - letters of alphabet (can represent actor names)
mat1<- matrix(round(runif(10*10)), 10, 10)
rownames(mat1)<-LETTERS[1:10]
colnames(mat1)<-LETTERS[1:10]

mat2<- matrix(round(runif(10*10)), 10, 10)
rownames(mat2)<-LETTERS[10:19]
colnames(mat2)<-LETTERS[10:19]

mat3<- matrix(round(runif(12*12)), 12, 12)
rownames(mat3)<-LETTERS[15:26]
colnames(mat3)<-LETTERS[15:26]

##Create matrix list
MATlist<-list(mat1,mat2,mat3)

##Adjust matrix 1 so that it has additional rows/actors not
##in the original matrix

mat1adjust<-ITNadjust(MATlist,1)
```

ITNblock_plot *ITN Blockmodel Plot*

Description

This function calculates block membership for the ITN and then plots the network, with node colour according to block membership.

Usage

```
ITNblock_plot(gs, LABEL)
```

Arguments

gs	International Trade Network - igraph object
LABEL	Should labels be present - TRUE/FALSE

Value

Network Plot - nodes coloured based on block membership

Examples

```
require(igraph)
require(sna)
require(intergraph)

##Create random International Trade Network (igraph object)
ITN<-erdos.renyi.game(75,0.05,directed = TRUE)

##Add edge weights
E(ITN)$weight<-runif(ecount(ITN), 0, 1)

##Blockmodel plot
block_plot<-ITNblock_plot(ITN,FALSE)
```

ITNblock_se *ITN Blockmodel & Structural Equivalence*

Description

This function calculates block membership for ITN and structural equivalence between countries

Usage

```
ITNblock_se(gs)
```

Arguments

gs	International Trade Network - igraph object

Value

List object containing block membership and structural equivalence matrix results

Examples

```
require(igraph)
require(sna)
require(intergraph)

##Create random International Trade Network (igraph object)
ITN<-erdos.renyi.game(50,0.05,directed = TRUE)

##Add edge weights
E(ITN)$weight<-runif(ecount(ITN), 0, 1)

##Blockmodel & structural equivalence analysis
blockse<-ITNblock_se(ITN)
```

ITNcentrality *ITN Centrality*

Description

This function calculates a number of centrality metrics for the weighted International Trade Network (ITN)

Usage

```
ITNcentrality(gs)
```

Arguments

gs	International Trade Network - igraph object

Value

Table of centrality results (dataframe)

Examples

```
require(igraph)
##Create random International Trade Network (igraph object)
ITN<-erdos.renyi.game(75,0.05,directed = TRUE)

##Add edge weights
E(ITN)$weight<-runif(ecount(ITN), 0, 1)

##Add vertex names
V(ITN)$name<-1:vcount(ITN)

##Calculate the centrality measures
ITNCENT<-ITNcentrality(ITN)
```

ITNcentrality_binary *ITN Centrality for binary networks*

Description

This function calculates a number of centrality metrics for the binary International Trade Network (ITN)

Usage

```
ITNcentrality_binary(gs)
```

Arguments

gs	International Trade Network - binary igraph object

Value

Table of centrality results (dataframe)

Examples

```
require(igraph)
##Create random International Trade Network (igraph object)
ITN<-erdos.renyi.game(75,0.05,directed = TRUE)


##Add vertex names
V(ITN)$name<-1:vcount(ITN)

##Calculate the centrality measures
ITNCENT<-ITNcentrality_binary(ITN)
```

ITNcluster *ITN Cluster*

Description

This function calculates cluster membership for ITN

Usage

```
ITNcluster(gs)
```

Arguments

gs	International Trade Network - igraph object (with region attribute)

Value

Cluster object containing various cluster membership results

Examples

```
##Load ITN
data(ELEnet16)

##Cluster Analysis
CLU<-ITNcluster(ELEnet16)
```

ITNcorr *ITN Correlation Plot*

Description

This function plots the correlation between degree and strength scores

Usage

```
ITNcorr(gs)
```

Arguments

gs	International Trade Network - igraph object

Value

Correlation plot

Examples

```
require(igraph)

##Create random International Trade Network (igraph object)
ITN<-erdos.renyi.game(75,0.05,directed = TRUE)

##Add edge weights
E(ITN)$weight<-runif(ecount(ITN), 0, 1)

##Plot correlation matrix between degree and strength scores.
corr_plot<-ITNcorr(ITN)
```

ITNdegdist *ITN Degree Distribution*

Description

This function plots the ITN (probability) degree distribtuion

Usage

```
ITNdegdist(gs)
```

Arguments

gs	International Trade Network - igraph object

Value

Panel of ITN degree distribution plots

Examples

```
require(igraph)

##Create random International Trade Network (igraph object)
ITN<-erdos.renyi.game(75,0.05,directed = TRUE)

##Plot degree distribution
deg_dist_plot<-ITNdegdist(ITN)
```

ITNdynamic *Dynamic ITN*

Description

This function produces a dynamic network object for ITNs. It cleans and adjusts the individual networks, so they are the same size. This dynamic network object can then be used to create animations, mapping changes over time and to calculate temporal network statistics

Usage

```
ITNdynamic(NETlist)
```

Arguments

NETlist	A list of International Trade Networks (igraph objects)

Value

It returns the Dynamic Network Object

Examples

```
require(igraph)

##Create a set of random International Trade Networks (igraph objects)
##and add vertex names
ITN1<-erdos.renyi.game(75,0.05,directed = TRUE)
V(ITN1)$name<-1:vcount(ITN1)
ITN2<-erdos.renyi.game(100,0.01,directed = TRUE)
V(ITN2)$name<-1:vcount(ITN2)
ITN3<-erdos.renyi.game(55,0.1,directed = TRUE)
V(ITN3)$name<-1:vcount(ITN3)

##Create network list
```

```
NETlist<-list(ITN1,ITN2,ITN3)

##Create Dynamic Network Object

ITNdyn<-ITNdynamic(NETlist)
```

ITNhistdegdist *ITN Histogram Degree Distribution*

Description

This function plots the histogram degree distribution for the ITN

Usage

```
ITNhistdegdist(gs)
```

Arguments

gs	International Trade Network - igraph object

Value

Panel of ITN histogram degree distribution plots

Examples

```
require(igraph)

##Create random International Trade Network (igraph object)
ITN<-erdos.renyi.game(75,0.05,directed = TRUE)

##Add edge weights
E(ITN)$weight<-runif(ecount(ITN), 0, 1)

##Plot degree distribution histogram
hist_deg_dist<-ITNhistdegdist(ITN)
```

ITNimvex *ITN - Exports vs Imports Plot*

Description

The following function produces a plot showing imports (in degree) vs exports (out degree). This allows us to identify whether in the ITN, countries that export high levels also import high levels. The plot can be produced for either weighted or binary import and export ties.

Usage

```
ITNimvex(gs, weighted)
```

Arguments

gs	International Trade Network - igraph object
weighted	TRUE - plot import strength vs export strength. FALSE - Import count Vs export count

Value

Imports Vs Exports Plot

Examples

```
require(igraph)

##Create random International Trade Network (igraph object)
ITN<-erdos.renyi.game(75,0.05,directed = TRUE)

##Add edge weights
E(ITN)$weight<-runif(ecount(ITN), 0, 1)

##Plot binary import vs exports
imvex_plot<-ITNimvex(ITN,FALSE)
```

ITNplotset *ITN Plots*

Description

This function creates a panel of four plots of the ITN for a quick inspection. These include plots: (i) highlighting clusters using the fast greedy algorithm.(ii)node colours for communities detected using the spinglass algorithm. (iii)nodes coloured by regional partition and (iv)with nodes coloured by regional partition and node size based on outdegree centrality.

Usage

```
ITNplotset(gs)
```

Arguments

gs	International Trade Network - igraph object

Value

Panel of ITN plots

Examples

```
##Load the network
data(ELEnet16)

##Plot set of network visualisations
ITNplotset(ELEnet16)
```

ITNproperties *ITN Properties*

Description

This function calculates network level properties for the ITN. These include: -Size (number of nodes) -Density -Reciprocity -Diameter -Average path length -Average node strength -Average Degree -Betweenness Centralisation -Closeness Centralisation -Eigenvector Centralisation -Out Degree Centralisation -In Degree Centralisation -All Degree Centralisation -Clustering coefficent (transitivity) -Clustering Weighted -Region Homophily -Degree Assortativity

Usage

```
ITNproperties(gs, weighted)
```

Arguments

gs	International Trade Network - igraph object
weighted	TRUE-weighted, FALSE-binary

Value

Table of centrality results (dataframe)

Examples

```
##Load the network
data(ELEnet16)

##Calculate the network properties
ITNPROP<-ITNproperties(ELEnet16,TRUE)
```

ITNproperties_base *ITN Properties Base*

Description

This function calculates network level properties for the ITN. These include: -Size (number of nodes) -Density -Reciprocity -Diameter -Average path length -Average node strength -Average Degree -Betweenness Centralisation -Closeness Centralisation -Eigenvector Centralisation -Out Degree Centralisation -In Degree Centralisation -All Degree Centralisation -Clustering coefficent (transitivity) -Clustering Weighted -Degree Assortativity

Usage

```
ITNproperties_base(gs, weighted)
```

Arguments

gs	International Trade Network - igraph object
weighted	TRUE-weighted, FALSE-binary

Value

Table of centrality results (dataframe)

Examples

```
##Load the network
data(ELEnet16)

##Calculate the network properties
ITNPROP<-ITNproperties_base(ELEnet16,TRUE)
```

ITN_make_plot *Single Clean ITN Plot*

Description

This function plots a single/clean ITN

Usage

```
ITN_make_plot(gs, LABEL, REGION)
```

Arguments

gs	International Trade Network - igraph object
LABEL	Should labels be present - TRUE/FALSE
REGION	Should nodes be coloured on the basis of region TRUE/FALSE

Value

Panel of ITN plots

Examples

```
##Load graph
data("ELEnet16")

##Otherwise download data from WITS and create an
##International Trade Network using WITSclean()

##Plot the network - No Label, colour by region
ITN_plot_example<-ITN_make_plot(ELEnet16,FALSE,TRUE)
```

ITN_map_plot *ITN plot on world map*

Description

This function plots the international trade network on a world map

Usage

```
ITN_map_plot(gs)
```

Arguments

gs	International Trade Network - igraph object

Value

Plot of the ITN on world map

Examples

```
require(maps)
##Load the ITN
data(ELEnet16)

## Plot ITN on map - node size based on outdegree
ITN_map_plot(ELEnet16)
```

`make_trade_network` *make_trade_network*

Description

This function takes (import) trade data and cleans it and transforms it into a network. This function can be applied to trade data downloaded from UN Comtrade (download csv and read into R as a dataframe), or any other trade data. You just make sure it has the following column names: reporter_iso, partner_iso and edge_weight. Some dataformats may have different names. Also - it is important to note that this function is for import data.

Usage

```
make_trade_network(DF, threshold, cutoff)
```

Arguments

`DF`	Dataframe of trade data downloaded (potentially using the comtradr package)
`threshold`	Apply a threshold - TRUE, Extract the backbone - FALSE
`cutoff`	Threshold - cutoff level, Backbone - significance level

Value

International Trade Network - igraph object

mixing_matrix_igraph *Mixing Matrix*

Description

This function calculates the mixing matrix for an igraph object

Usage

```
mixing_matrix_igraph(gs, attrname)
```

Arguments

gs	igraph object.
attrname	Attribute name (vertex attribute)

Value

Mixing matrix

Examples

```
require(igraph)
##Create random International Trade Network (igraph object)
gs<-erdos.renyi.game(50,0.05,directed = TRUE)

##Add vertex attributes
V(gs)$LETTER<-rep(LETTERS[1:5],10)

##Add vertex names
V(gs)$name<-1:vcount(gs)

##Calculate mixing matrix
mixing_matrix<-mixing_matrix_igraph(gs,"LETTER")
```

plot_degree_distribution *Plot Degree Distribution*

Description

This function plots degree distribution for any graph

Usage

```
plot_degree_distribution(graph, a)
```

Arguments

graph	igraph object
a	mode - "in","out","all

Value

Panel of ITN degree distribution plots

Examples

```
require(igraph)
##Create random International Trade Network (igraph object)
ITN<-erdos.renyi.game(75,0.05,directed = TRUE)

##Plot out degree distribution
plot_degree_distribution(ITN,"in")
```

---

receiver_mat *receiver_mat*

Description

This takes a dataframe of node attributes and convert one into a matrix of receiver attributes

Usage

```
receiver_mat(DF, attrname)
```

Arguments

DF	Dataframe of node attribute
attrname	names of the attribute from the dataframe to create the matrix for.

Value

Receiver matrix

region_circle_plot *region_circle_plot*

Description

This function creates a chord diagram/circle plot for levels of trade between regional partitions

Usage

```
region_circle_plot(gs)
```

Arguments

gs	igraph ITN object (with attributes added)

Value

Circle Plot

Examples

```
##Load graph
data("ELEnet16")

##Create region circle plot
region_circle_plot(ELEnet16)
```

reorder_df *reorder_df*

Description

Reorders the rows of one dataframe according to another vector (id vector)

Usage

```
reorder_df(df, col_sort, reorder_data)
```

Arguments

df	dataframe to reorder
col_sort	column on which the rows will be reordered
reorder_data	vector with the new order

Value

Reordered dataframe

Examples

```
df <- data.frame(a = letters[1:3],b = LETTERS[4:6],c = 7:9)

reorder_data<-c("c","a","b")

df_new<-reorder_df(df,"a",reorder_data)

df_new
```

---

round_df *round_df*

Description

This function rounds the numeric variables in a dataframe containing numeric and non-numeric data

Usage

```
round_df(x, digits)
```

Arguments

x	dataframe
digits	digits to round to

Value

Dataframe with rounded numbers

Examples

```
##Create dataframe
ID = c("a","b","c","d","e")
Value1 = c(3.445662,6.44566,8.75551,1.114522,1.5551)
Value2 = c(8.2,1.7,6.4,19.45459,10.34524)
df<-data.frame(ID,Value1,Value2)

##Round to 2 digits
rounddf<-round_df(df,2)
```

sender_mat *sender_mat*

Description

This takes a dataframe of node attributes and convert one into a matrix of sender attributes

Usage

```
sender_mat(DF, attrname)
```

Arguments

DF	Dataframe of node attribute
attrname	names of the attribute from the dataframe to create the matrix for.

Value

Sender matrix

WITSclean *WITS data clean*

Description

This function takes (import) trade data downloaded from WITS, cleans it and transforms it into a network. Adding a number of country level attributes to nodes in the network, including: regional partition, GDP, GDP per capita, GDP growth and FDI.

Usage

```
WITSclean(CSVfile, YEAR, threshold, cutoff)
```

Arguments

CSVfile	WITS csv file
YEAR	Year
threshold	Apply a threshold - TRUE, Extract the backbone - FALSE
cutoff	Threshold - cutoff level, Backbone - significance level

Value

International Trade Network - igraph object

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