

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 of 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.

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License GPL-3

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adjust_mat

Adjust Matrix

Description

adjust the dimensions of a source object to the dimensions of a target object

Usage

```
adjust_mat(
  source,
  target,
  remove = TRUE,
  add = TRUE,
  value = NA,
  returnlabels = FALSE
)
```

Arguments

source	A matrix which should be adjusted (one-mode & directed).
target	A matrix (one-mode & directed) to which the source object is compared with regard to its labels.
remove	Should rows and columns that are not present in the target object be removed?
add	Should rows and columns that are present in the target object but not in the source object be added to the source object?
value	The value to be inserted if a new row or column is added. By default, new cells are filled with NA values, but other sensible values may include -Inf or 0.
returnlabels	Return a list of added and removed row and column labels rather than the actual matrix, vector, or network object?

Value

Matrix

cap_lat_lon	<i>cap_lat_lon</i>
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Description

Dataframe of capital city latitude and longitude coordinates

Usage

cap_lat_lon

ComtradrClean	<i>Comtradr data clean</i>
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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 which is in the same format as the comtradr dataframe.

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

Examples

```
##download data using comtradr
#require(comtradr)

##Download the trade data for tomatoes - code 0702
##All countries, Year - 2016
#ex_2 <- ct_search(reporters = "All",
#                  partners = c("USA","China",
#                               "Germany","Canada","Mexico"),
#                  trade_direction = "imports",
#                  start_date = "2016-01-01",
#                  end_date = "2016-12-31",
#                  commod_codes = "0702")

##this then gives a data frame which
##we can clean using the following function:
tomatoesITN<-Comtradrclean(ex_2,2016,TRUE,0.01)

##We apply a threshold - only retaining ties that are at least 0.01%
##of total tomatoes trade (amongst these countries)
```

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.0119678>

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	<i>Group level E-I Index</i>
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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")
```

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	<i>get.backbone</i>
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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	<i>isEmpty</i>
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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	<i>Adjust ITN</i>
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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	<i>ITN Centrality</i>
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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	<i>ITN Centrality for binary networks</i>
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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	<i>ITN Correlation Plot</i>
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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	<i>ITN Degree Distribution</i>
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Description

This function plots the ITN (probability) degree distribuion

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	<i>ITN Histogram Degree Distribution</i>
----------------	--

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 coefficient (transitivity) -Clustering Weighted -Region Homophily -Degree Assortativity

Usage

```
ITNproperties(gs)
```

Arguments

gs International Trade Network - igraph object

Value

Table of centrality results (dataframe)

Examples

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

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

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	<i>ITN plot on world map</i>
--------------	------------------------------

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)
```

mixing_matrix_igraph	<i>Mixing Matrix</i>
----------------------	----------------------

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")
```

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("EENet16")

##Create region circle plot
region_circle_plot(EENet16)
```

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)
```

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

Examples

```
##Create an igraph object from international
##trade data downloaded from WITS

##Applies a threhold
##only retains ties that are at least
## 0.01% of total trade

ITN<-WITSclean("WITS_CSV_FILE_NAME.csv",2015,TRUE,0.01)
```

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