

# Package ‘IVCor’

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**Type** Package

**Title** A Robust Integrated Variance Correlation

**Version** 0.1.0

**Description** A integrated variance correlation is proposed to measure the dependence between a categorical or continuous random variable and a continuous random variable or vector.  
This package is designed to estimate the new correlation coefficient with parametric and non-parametric approaches.  
Test of independence for different problems can also be implemented via the new correlation coefficient with this package.

**License** GPL-3

**Encoding** UTF-8

**Imports** splines, quantreg, BwQuant, quantdr, stats

**RoxygenNote** 7.2.3

**Suggests** knitr, mvtnorm, rmarkdown, testthat (>= 3.0.0)

**VignetteBuilder** knitr

**Config/testthat/edition** 3

**NeedsCompilation** no

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|     |                                        |
|-----|----------------------------------------|
| IVC | <i>Integrated Variance Correlation</i> |
|-----|----------------------------------------|

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**Description**

This function is used to calculate the integrated variance correlation between two random variables or between a random variable and a multivariate random variable

**Usage**

```
IVC(y, x, K, NN = 3, type)
```

**Arguments**

- y is a numeric vector
- x is a numeric vector or a data matrix
- K is the number of quantile levels
- NN is the number of B spline basis, default is 3
- type is an indicator for measuring linear or nonlinear correlation, "linear" represents linear correlation and "nonlinear" represents linear or nonlinear correlation using B splines

**Value**

The value of the corresponding sample statistic

**Examples**

```
# linear model
n=100
x=rnorm(n)
y=3*x+rnorm(n)

IVC(y,x,K=5,type="linear")
# nonlinear model
n=100
p=3
x=matrix(NA,nrow=n,ncol=p)
for(i in 1:p){
  x[,i]=rnorm(n)
```

```

}
y=cos(x[,1]+x[,2])+x[,3]^2+rnorm(n)
IVC(y,x,K=5,type="nonlinear")

```

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IVCCA

---

*Integrated Variance Correlation with Discrete Response Variable*


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## Description

This function is used to calculate the integrated variance correlation between a discrete response variable and a continuous random variable

## Usage

```
IVCCA(y, x, K)
```

## Arguments

|   |                                    |
|---|------------------------------------|
| y | is the categorical response vector |
| x | is a numeric vector                |
| K | is the number of quantile levels   |

## Value

The value of the corresponding sample statistic

## Examples

```

n=100
y=sample(rep(1:3), n, replace = TRUE, prob = c(1/3,1/3,1/3))
x=c()
for(i in 1:n){
  x[i]=rnorm(1,mean=2*y[i],sd=1)
}

IVCCA(y,x,K=5)

```

---

|        |                                                                                    |
|--------|------------------------------------------------------------------------------------|
| IVCCAT | <i>Integrated Variance Correlation Based Hypothesis Test for Discrete Response</i> |
|--------|------------------------------------------------------------------------------------|

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### Description

This function is used to test independence between a categorical variable and a continuous variable using integrated variance correlation

### Usage

```
IVCCAT(y, x, K, num_per, type)
```

### Arguments

|         |                                                                                                                                                                                                                                                                                                  |
|---------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| y       | is a categorical response vector                                                                                                                                                                                                                                                                 |
| x       | is a numeric vector                                                                                                                                                                                                                                                                              |
| K       | is the number of quantile levels                                                                                                                                                                                                                                                                 |
| num_per | is the number of permutation times                                                                                                                                                                                                                                                               |
| type    | is an indicator for fixed number of categories or infinity number of categories, "fixed" represents number of categories is fixed, then a permutation test is used, "infinity" represents number of categories is infinite, then an asymptotic normal distribution is used to calculate p values |

### Value

The p-value of the corresponding hypothesis test

### Examples

```
# small R
n=100
x=runif(n,0,1)
y=sample(rep(1:3), n, replace = TRUE, prob = c(1/3,1/3,1/3))

IVCCAT(y,x,K=5,num_per=20,type = "fixed")

# large R
n=200
y=sample(rep(1:20), n, replace = TRUE, prob = rep(1/20,20))
mu_x=sample(c(1,2,3,4),20,replace = TRUE,prob = c(1/4,1/4,1/4,1/4))
x=c()
for (i in 1:n) {
  x[i]=2*mu_x[y[i]]+rcauchy(1)
}

IVCCAT(y,x,K=10,type = "infinity")
```

---

|            |                                                                                                         |
|------------|---------------------------------------------------------------------------------------------------------|
| IVCCA_crit | <i>Critical Values for Integrated Variance Correlation Based Hypothesis Test with Discrete Response</i> |
|------------|---------------------------------------------------------------------------------------------------------|

---

**Description**

This function is used to calculate the critical values for integrated variance correlation test with discrete response at significance level 0.1, 0.05 and 0.01

**Usage**

```
IVCCA_crit(R, N = 500, realizations)
```

**Arguments**

|              |                                                                                                  |
|--------------|--------------------------------------------------------------------------------------------------|
| R            | is the number of categories                                                                      |
| N            | is a integer as large as possible, default is 500                                                |
| realizations | is the the number of replication times for simulating the distribution under the null hypothesis |

**Value**

The critical values at significance level 0.1, 0.05 and 0.01

**Examples**

```
IVCCA_crit(R=5,N=500,realizations=100)
```

---

|        |                                                                     |
|--------|---------------------------------------------------------------------|
| IVCLLQ | <i>Integrated Variance Correlation with Local Linear Estimation</i> |
|--------|---------------------------------------------------------------------|

---

**Description**

This function is used to calculate the integrated variance correlation between two random variables with local linear estimation

**Usage**

```
IVCLLQ(y, x, K)
```

**Arguments**

|   |                                  |
|---|----------------------------------|
| y | is a numeric vector              |
| x | is a numeric vector              |
| K | is the number of quantile levels |

**Value**

The value of the corresponding sample statistic

**Examples**

```
n=100
x=rnorm(n)
y=exp(x)+rnorm(n)

IVCLLQ(y,x,K=4)
```

---

IVCT

---

*Integrated Variance Correlation Based Hypothesis Test*


---

**Description**

This function is used to test significance of linear or nonlinear correlation using integrated variance correlation

**Usage**

```
IVCT(y, x, K, num_per, NN = 3, type)
```

**Arguments**

|         |                                                                                                                                                                                  |
|---------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| y       | is the response vector                                                                                                                                                           |
| x       | is a numeric vector or a data matrix                                                                                                                                             |
| K       | is the number of quantile levels                                                                                                                                                 |
| num_per | is the number of permutation times                                                                                                                                               |
| NN      | is the number of B spline basis, default is 3                                                                                                                                    |
| type    | is an indicator for measuring linear or nonlinear correlation, "linear" represents linear correlation and "nonlinear" represents linear or nonlinear correlation using B splines |

**Value**

The p-value of the corresponding hypothesis test

**Examples**

```
# linear model
n=100
x=rnorm(n)
y=rnorm(n)

IVCT(y,x,K=5,num_per=20,type = "linear")
# nonlinear model
```

```

n=100
p=4
x=matrix(NA,nrow=n,ncol=p)
for(i in 1:p){
  x[,i]=runif(n,0,1)
}
y=3*ifelse(x[,1]>0.5,1,0)*x[,2]+3*cos(x[,3])^2*x[,1]+3*(x[,4]^2-1)*x[,1]+rnorm(n)

IVCT(y,x,K=5,num_per=20,type = "nonlinear")

```

---

|         |                                                                                           |
|---------|-------------------------------------------------------------------------------------------|
| IVCTLLQ | <i>Integrated Variance Correlation Based Hypothesis Test with Local Linear Estimation</i> |
|---------|-------------------------------------------------------------------------------------------|

---

### Description

This function is used to test significance using integrated variance correlation with local linear estimation

### Usage

```
IVCTLLQ(y, x, K, num_per)
```

### Arguments

|         |                                    |
|---------|------------------------------------|
| y       | is a numeric vector                |
| x       | is a numeric vector                |
| K       | is the number of quantile levels   |
| num_per | is the number of permutation times |

### Value

The p-value of the corresponding hypothesis test

### Examples

```

n=100
x=runif(n,-1,1)
y=2*cos(2*x)+rnorm(n)

IVCTLLQ(y,x,K=5,num_per=100)

```

---

|               |                                                                                    |
|---------------|------------------------------------------------------------------------------------|
| IVCT_Interval | <i>Integrated Variance Correlation Based Interval Independence Hypothesis Test</i> |
|---------------|------------------------------------------------------------------------------------|

---

### Description

This function is used to test interval independence using integrated variance correlation

### Usage

```
IVCT_Interval(y, x, tau1, tau2, K, num_per, NN = 3, type)
```

### Arguments

|         |                                                                                                                                                                                  |
|---------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| y       | is the response vector                                                                                                                                                           |
| x       | is a numeric vector or a data matrix                                                                                                                                             |
| tau1    | is the minimum quantile level                                                                                                                                                    |
| tau2    | is the maximum quantile level                                                                                                                                                    |
| K       | is the number of quantile levels                                                                                                                                                 |
| num_per | is the number of permutation times                                                                                                                                               |
| NN      | is the number of B spline basis, default is 3                                                                                                                                    |
| type    | is an indicator for measuring linear or nonlinear correlation, "linear" represents linear correlation and "nonlinear" represents linear or nonlinear correlation using B splines |

### Value

The p-value of the corresponding hypothesis test

### Examples

```
require("mvtnorm")
n=100
p=3
pho1=0.5
mean_x=rep(0,p)
sigma_x=matrix(NA,nrow = p,ncol = p)
for (i in 1:p) {
  for (j in 1:p) {
    sigma_x[i,j]=pho1^(abs(i-j))
  }
}
x=rmvnorm(n, mean = mean_x, sigma = sigma_x,method = "chol")
y=rnorm(n)

IVCT_Interval(y,x,tau1=0.5,tau2=0.75,K=5,num_per=20,type = "linear")
```

```

n=100
x_til=runif(n,min=-1,max=1)
y_til=rnorm(n)
epsilon=rnorm(n)
x=x_til+2*epsilon*ifelse(x_til<=-0.5&y_til<=-0.675,1,0)
y=y_til+2*epsilon*ifelse(x_til<=-0.5&y_til<=-0.675,1,0)

IVCT_Interval(y,x,tau1=0.6,tau2=0.8,K=5,num_per=20,type = "nonlinear")

```

---

|          |                                                                                  |
|----------|----------------------------------------------------------------------------------|
| IVC_crit | <i>Critical Values for Integrated Variance Correlation Based Hypothesis Test</i> |
|----------|----------------------------------------------------------------------------------|

---

### Description

This function is used to calculate the critical values for integrated variance correlation test at significance level 0.1, 0.05 and 0.01

### Usage

```
IVC_crit(N = 500, realizations)
```

### Arguments

|              |                                                                                                  |
|--------------|--------------------------------------------------------------------------------------------------|
| N            | is a integer as large as possible, default is 500                                                |
| realizations | is the the number of replication times for simulating the distribution under the null hypothesis |

### Value

The critical values at significance level 0.1, 0.05 and 0.01

### Examples

```
IVC_crit(N=500,realizations=100)
```

IVC\_Interval

*Integrated Variance Correlation for Interval Independence***Description**

This function is used to calculate the integrated variance correlation to measure interval independence

**Usage**

```
IVC_Interval(y, x, K, tau1, tau2, NN = 3, type)
```

**Arguments**

|      |                                                                                                                                                                                  |
|------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| y    | is a numeric vector                                                                                                                                                              |
| x    | is a numeric vector or a data matrix                                                                                                                                             |
| K    | is the number of quantile levels                                                                                                                                                 |
| tau1 | is the minimum quantile level                                                                                                                                                    |
| tau2 | is the maximum quantile level                                                                                                                                                    |
| NN   | is the number of B spline basis, default is 3                                                                                                                                    |
| type | is an indicator for measuring linear or nonlinear correlation, "linear" represents linear correlation and "nonlinear" represents linear or nonlinear correlation using B splines |

**Value**

The value of the corresponding sample statistic for interval independence

**Examples**

```
# linear model
require("mvtnorm")
n=100
p=3
pho1=0.5
mean_x=rep(0,p)
sigma_x=matrix(NA,nrow = p,ncol = p)
for (i in 1:p) {
  for (j in 1:p) {
    sigma_x[i,j]=pho1^(abs(i-j))
  }
}
x=rmvnorm(n, mean = mean_x, sigma = sigma_x,method = "chol")
y=2*(x[,1]+x[,2]+x[,3])+rnorm(n)

IVC_Interval(y,x,K=5,tau1=0.4,tau2=0.6,type="linear")
# nonlinear model
```

```
n=100
x=runif(n,min=-2,max=2)
y=exp(x^2)*rnorm(n)

IVC_Interval(y,x,K=5,tau1=0.4,tau2=0.6,type="nonlinear")
```

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