Package ‘multDM’

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Type Package

Title Multivariate Version of the Diebold-Mariano Test

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Description Allows to perform the multivariate version of the Diebold-Mariano test for equal predictive ability of multiple forecast comparison. Main reference: Mariano, R.S., Preve, D. (2012) <doi:10.1016/j.jeconom.2012.01.014>.

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DM.test *Computes Diebold-Mariano Test for the Equal Predictive Accuracy.*

Description

This function computes Diebold-Mariano test for the equal predictive accuracy. The null hypothesis of this test is that two forecasts have the same accuracy. The alternative hypothesis can be specified as "Both forecasts have different accuracy", "The first forecast is less accurate than the second forecast", or "The first forecast is more accurate than the second forecast".

Usage

```
DM.test(f1,f2,y,loss.type="SE",h,c=FALSE,H1="same")
```

Arguments

`f1`	`vector` of the first forecast
`f2`	`vector` of the second forecast
`y`	`vector` of the real values of the modelled time-series
`loss.type`	method to compute the loss function, `loss.type="SE"` will use squared errors, `loss.type="AE"` will use absolute errors, `loss.type="SPE"` will use squred proportional error (useful if errors are heteroskedastic), `loss.type="ASE"` will use absolute scaled error, if `loss.type` will be specified as some `numeric`, then the function of type `exp(loss.type*errors)-1-loss.type*errors` will be used (useful when it is more costly to underpredict `y` than to overpredict), if not specified `loss.type="SE"` is used
`h`	`numeric` dentoing that the forecast `h`-steps ahead are evaluated, if not specified `h=1` is used
`c`	`logical` indicating if Harvey-Leybourne-Newbold correction for small samples should be used, if not specified `c=FALSE` is used
`H1`	alternative hypothesis, `H1="same"` for "both forecasts have different accuracy", `H1="more"` for "the first forecast is more accurate than the second forecast", `H1="less"` for "the first forecast is less accurate than the second forecast", if not specified `H1="same"` is taken

Value

class `htest` object, `list` of

`statistic`	test statistic
`parameter`	`h`, forecast horizon used
`alternative`	alternative hypothesis of the test
`p.value`	p-value
`method`	name of the test
`data.name`	names of the tested time-series

References

Diebold, F.X., Mariano, R. 1995. Comparing predictive accuracy. *Journal of Business and Economic Statistics* **13**, 253–265.

Harvey, D., Leybourne, S., Newbold, P., 1997. Testing the equality of prediction mean squared errors. *International Journal of Forecasting* **13**, 281–291.

Hyndman, R.J., Koehler, A.B. 2006. Another look at measures of forecast accuracy. *International Journal of Forecasting* **22**, 679–688.

Taylor, S. J., 2005. *Asset Price Dynamics, Volatility, and Prediction*, Princeton University Press.

Triacca, U., 2018. *Comparing Predictive Accuracy of Two Forecasts*, http://www.phdeconomics.sssup.it/documents/Lesson19.pdf.

Examples

```
data(MDMforecasts)
ts <- MDMforecasts$ts
forecasts <- MDMforecasts$forecasts
DM.test(f1=forecasts[,1],f2=forecasts[,2],y=ts,loss="SE",h=1,c=FALSE,H1="same")
```

---

d_t *Computes Loss Differential.*

Description

This function computes loss differential, i.e., differences between losses from $k+1$-th and k-th models.

Usage

```
d_t(e)
```

Arguments

e	matrix of loss functions, columns correspond to time index, and rows to different models

Value

matrix of loss differentials

References

Mariano R.S., Preve, D., 2012. Statistical tests for multiple forecast comparison. *Journal of Econometrics* **169**, 123–130.

Examples

```
data(MDMforecasts)
ts <- MDMforecasts$ts
forecasts <- MDMforecasts$forecasts
l <- loss(realized=ts,evaluated=forecasts,loss.type="SE")
d <- d_t(l)
```

---

loss *Computes Loss Function.*

Description

This function computes various loss functions for given realized values of time-series and a collection of forecasts.

Usage

```
loss(realized,evaluated,loss.type)
```

Arguments

`realized`	`vector` of the real values of the modelled time-series
`evaluated`	`matrix` of the forecasts, columns correspond to time index, rows correspond to different models
`loss.type`	method to compute the loss function, `loss.type="SE"` will use squared errors, `loss.type="AE"` will use absolute errors, `loss.type="SPE"` will use squred proportional error (useful if errors are heteroskedastic), `loss.type="ASE"` will use absolute scaled error, if `loss.type` will be specified as some `numeric`, then the function of type `exp(loss.type*errors)-1-loss.type*errors` will be used (useful when it is more costly to underpredict `realized` than to overpredict)

Value

`matrix` with columns corresponding to time index and rows to different models

References

Hyndman, R.J., Koehler, A.B. 2006. Another look at measures of forecast accuracy. *International Journal of Forecasting* **22**, 679–688.

Taylor, S. J., 2005. *Asset Price Dynamics, Volatility, and Prediction*, Princeton University Press.

Triacca, U., 2018. *Comparing Predictive Accuracy of Two Forecasts*, http://www.phdeconomics.sssup.it/documents/Lesson19.pdf.

Examples

```
data(MDMforecasts)
ts <- MDMforecasts$ts
forecasts <- MDMforecasts$forecasts
l <- loss(realized=ts,evaluated=forecasts,loss.type="SE")
```

MDM.selection — *Selects Models with Outstanding Predictive Ability basing on Multivariate Diebold-Mariano Test.*

Description

This function selects models with outstanding predictive ability basing on multivariate Diebold-Mariano test `MDM.test`.

Usage

```
MDM.selection(realized,evaluated,q,alpha,statistic="Sc",loss.type="SE")
```

Arguments

`realized`	`vector` of the real values of the modelled time-series
`evaluated`	`matrix` of the forecasts, columns correspond to time index, rows correspond to different models
`q`	`numeric` indicating a lag length beyond which we are willing to assume that the autocorrelation of loss differentials is essentially zero
`alpha`	`numeric` indicating a significance level for multivariate Diebold-Mariano tests
`statistic`	`statistic="S"` for the basic version of the test, and `statistic="Sc"` for the finite-sample correction, if not specified `statistic="Sc"` is used
`loss.type`	method to compute the loss function, `loss.type="SE"` will use squared errors, `loss.type="AE"` will use absolute errors, `loss.type="SPE"` will use squred proportional error (useful if errors are heteroskedastic), `loss.type="ASE"` will use absolute scaled error, if `loss.type` will be specified as some `numeric`, then the function of type `exp(loss.type*errors)-1-loss.type*errors` will be used (useful when it is more costly to underpredict `realized` than to overpredict), if not specified `loss.type="SE"` is used

Value

class `MDM` object, `list` of

`outcomes`	`matrix` with mean losses for the selected models, statistics corresponding to losses differentials and ranking of these statistics
`p.value`	`numeric` of p-value from the procedure, i.e., p-value of multivariate Diebold-Mariano test from the last step
`alpha`	`alpha`, i.e., the chosen significance level
`eliminated`	`numeric` indicating the number of eliminated models

References

Mariano R.S., Preve, D., 2012. Statistical tests for multiple forecast comparison. *Journal of Econometrics* **169**, 123–130.

Examples

```
data(MDMforecasts)
ts <- MDMforecasts$ts
forecasts <- MDMforecasts$forecasts
MDM.selection(realized=ts,evaluated=forecasts,q=10,alpha=0.1,statistic="S",loss.type="AE")
```

`MDM.test` *Computes Multivariate Diebold-Mariano Test for the Equal Predictive Accuracy of Two or More Non-nested Forecasting Models.*

Description

This function computes multivariate Diebold-Mariano test for the equal predictive accuracy of two or more non-nested forecasting models. The null hypothesis of this test is that the evaluated forecasts have the same accuracy. The alternative hypothesis is that Equal predictive accuracy (EPA) does not hold.

Usage

```
MDM.test(realized,evaluated,q,statistic="Sc",loss.type="SE")
```

Arguments

`realized`	`vector` of the real values of the modelled time-series
`evaluated`	`matrix` of the forecasts, columns correspond to time index, rows correspond to different models
`q`	`numeric` indicating a lag length beyond which we are willing to assume that the autocorrelation of loss differentials is essentially zero
`statistic`	`statistic="S"` for the basic version of the test, and `statistic="Sc"` for the finite-sample correction, if not specified `statistic="Sc"` is used
`loss.type`	method to compute the loss function, `loss.type="SE"` will use squared errors, `loss.type="AE"` will use absolute errors, `loss.type="SPE"` will use squred proportional error (useful if errors are heteroskedastic), `loss.type="ASE"` will use absolute scaled error, if `loss.type` will be specified as some `numeric`, then the function of type `exp(loss.type*errors)-1-loss.type*errors` will be used (useful when it is more costly to underpredict `realized` than to overpredict), if not specified `loss.type="SE"` is used

Value

class htest object, list of

statistic	test statistic
parameter	q, a lag length
alternative	alternative hypothesis of the test
p.value	p-value
method	name of the test
data.name	names of the tested objects

References

Mariano R.S., Preve, D., 2012. Statistical tests for multiple forecast comparison. *Journal of Econometrics* **169**, 123–130.

Examples

```
data(MDMforecasts)
ts <- MDMforecasts$ts
forecasts <- MDMforecasts$forecasts
MDM.test(realized=ts,evaluated=forecasts,q=10,statistic="S",loss.type="AE")
```

MDMforecasts *Sample Data.*

Description

Sample artificial data.

Usage

```
data(MDMforecasts)
```

Format

MDMforecasts is list object such that

MDMforecasts$ts is vector of time-series which is of interest to model

- MDMforecasts$forecasts is matrix of 20 different forecasts of ts from 20 different forecasting models, each row represents different forecast and time is indexed by columns

Examples

```
data(MDMforecasts)
ts <- MDMforecasts$ts
forecasts <- MDMforecasts$forecasts
MDM.test(realized=ts,evaluated=forecasts,q=10,statistic="S",loss.type="AE")
```

oilforecasts *Sample Data from Crude Oil Price Forecasting.*

Description

Forecasts obtained from various methods applied to crude oil price.

Usage

```
data(oilforecasts)
```

Format

`oilforecasts` is `matrix` object such that its rows correspond to forecasts from various methods, i.e.,

`REALIZED` is the forecasted time-series,

- `DMA.DOW` is the forecast from Dynamic Model Averaging with the dynamic Occam's window,
- `BMA.DOW` is the forecast from Bayesian Model Averaging with the dynamic Occam's window,
- `DMA.1V` is the forecast from Dynamic Model Averaging applied only to one-variable models,
- `BMA.1V` is the forecast from Bayesian Model Averaging applied only to one-variable models,
- `DMS.1V` is the forecast from Dynamic Model Selection applied only to one-variable models,
- `BMS.1V` is the forecast from Bayesian Model Selection applied only to one-variable models,
- `TVP` is the forecast from Time-Varying Parameters regression,
- `LASSO` is the forecast from LASSO regression,
- `RIDGE` is the forecast from RIDGE regression,
- `DYN.EL.NET` is the forecast from the elastic net regression, with the elastic net mixing parameter changing with time index,
- `LARS` is the forecast from the least-angle regression,
- `B.LASSO` is the forecast from the Bayesian LASSO regression,
- `B.RIDGE` is the forecast from the Bayesian RIDGE regression,
- `ARIMA` is the forecast from the best ARIMA model according to AIC,
- `NAIVE` is the naive forecast, i.e., the last observation is taken as a one-step ahead prediction,
- `MA` is the moving average.

Details

The data were taken from Juvenal and Petrella (2015). They cover the period between 1971 and 2009, and are in quarterly freqency. Time-series with missing observations were excluded from the original data set, resulting finally in 127 explanatory variables, instead of 150 in the original data set. In particular, the excluded time-series are the ones which start date is after 1971. The dependent time-series is the average world price of oil taken in logarithmic differences. The independent time-series represent various stationarity tranformations of macroeconomic and financial variables of the

G7 countries and from the oil market, global economic activity and various commodity prices. The details of the original data set are given in the paper by Juvenal and Petrella (2015). The forecasting with various models, based on this data set, was done by the author of this package, just to provide some more concrete example set of forecasts. The independent variables were taken in the first lags. The forgetting parameters in DMA/DMS models were set to 0.99, resulting in the effective rolling window size of 100. Therefore, such a window was taken for the moving average. LASSO and RIDGE (also in the Bayesian versions), the elastic net, the least-angle regression and ARIMA models were estimated in rolling windows of the size of 100 observations. First 100 observations were excluded, and `oilforecasts` consists of the remaining last observations. The estimations were done with the following packages `fDMA`, `forecast`, `glmnet`, `lars` and `monomvn`.

References

Drachal, K. 2017. fDMA: Dynamic Model Averaging and Dynamic Model Selection for continuous outcomes. https://CRAN.R-project.org/package=fDMA

Friedman, J., Hastie, T., Tibshirani, R. 2010. Regularization paths for generalized linear models via coordinate descent. *Journal of Statistical Software* **33**, 1–22.

Gramacy, R.B. 2017. monomvn: Estimation for Multivariate Normal and Student-t Data with Monotone Missingness. https://CRAN.R-project.org/package=monomvn

Hastie, T., Efron, B. 2013. lars: Least Angle Regression, Lasso and Forward Stagewise. https://CRAN.R-project.org/package=lars

Hyndman, R.J., Khandakar. Y. 2008. Automatic time series forecasting: the forecast package for R. *Journal of Statistical Software* **26**, 1–22.

Juvenal, L., Petrella, I. 2015. Speculation in the oil market. *Journal of Applied Econometrics* **30**, 612–649.

Examples

```
data(oilforecasts)
ts <- oilforecasts[1,]
forecasts <- oilforecasts[-1,]
l <- loss(realized=ts,evaluated=forecasts,loss.type="SE")
d <- d_t(l)
q <- TB_MA(d=d,q.max=4)
MDM.selection(realized=ts,evaluated=forecasts,q=q,alpha=0.1,statistic="Sc",loss.type="SE")
```

---

print.MDM *Prints* MDM *Object.*

Description

The function prints selected outcomes obtained from `MDM.selection`.

Usage

```
## S3 method for class 'MDM'
print(x, ...)
```

Arguments

x	an object of MDM class
...	not used

Details

The function prints models with outstanding predictive ability, their mean loss function, statistics corresponding to their loss differentials (they are the number of the models less one), and orders these statistics. It also prints the p-value of the test and the number of eliminated models. If no models with outstanding predictive ability were found, the funtions prints such an information.

Examples

```
data(MDMforecasts)
ts <- MDMforecasts$ts
forecasts <- MDMforecasts$forecasts
m <- MDM.selection(realized=ts,evaluated=forecasts,q=10,alpha=0.1,statistic="S",loss.type="AE")
print(m)
```

TB_AR_test *Computes Tiao-Box Test for Autocorrelation.*

Description

This function computes Tiao-Box test for autocorrelation, i.e, coefficient of p-th lag in VAR(p) model. Its null hypothesis is that p-th lag is not essential. The alternative hypothesis is that it is essential.

Usage

```
TB_AR_test(d,p)
```

Arguments

d	matrix of time-series, assumed to be the stationary VARMA type, columns correspond to time index, and rows to different time-series
p	numeric indicating a lag length beyond which we are willing to assume that the autocorrelation is essentially zero

Value

class htest object, list of

statistic	test statistic
parameter	q, a lag length
alternative	alternative hypothesis of the test
p.value	p-value
method	name of the test
data.name	name of the tested time-series

References

Tiao, G.C., Box, G.E.P. 1981. Modeling multiple times series with applications. *Journal of the American Statistical Association* **76**, 802–816.

Examples

```
data(MDMforecasts)
ts <- MDMforecasts$ts
forecasts <- MDMforecasts$forecasts
l <- loss(realized=ts,evaluated=forecasts,loss.type="SE")
d <- d_t(l)
TB_AR_test(d=d,p=10)
```

TB_MA *Checks for a Lag in VMA Process with Tiao-Box Procedure.*

Description

This function helps to find a lag in stationary VMA process with Tiao-Box procedure, i.e., the lag length beyond which we are willing to assume that the autocorrelation is essentially zero.

Usage

```
TB_MA(d,q.max)
```

Arguments

d	`matrix` of time-series, assumed to be the stationary VARMA type, columns correspond to time index, and rows to different time-series
q.max	`numeric` indicating the maximum number of lag to be considered

Details

The function searches for correlations smaller than $-2n^{-0.5}$ or higher than $2n^{-0.5}$, where n is the lenght of the time-series.

Value

`numeric` indicating the found lag length

References

Tiao, G.C., Box, G.E.P. 1981. Modeling multiple times series with applications. *Journal of the American Statistical Association* **76**, 802–816.

Examples

```
data(MDMforecasts)
ts <- MDMforecasts$ts
forecasts <- MDMforecasts$forecasts
l <- loss(realized=ts,evaluated=forecasts,loss.type="SE")
d <- d_t(l)
TB_MA(d=d,q.max=10)
```

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