Package ‘intrinsicFRP’

November 30, 2023

Title  An R Package for Factor Model Asset Pricing
Version  2.0.0
Date  2023-11-28
Maintainer  Alberto Quaini <alberto91quaini@gmail.com>
License  GPL (>= 3)
URL  https://github.com/a91quaini/intrinsicFRP
BugReports  https://github.com/a91quaini/intrinsicFRP/issues
Encoding  UTF-8
RoxygenNote  7.2.3
Description

Tests the null hypothesis of reduced rank in the matrix of regression loadings for test asset excess returns on risk factors using the Chen-Fang (2019) doi:10.3982/QE1139 beta rank test. The test applies the Kleibergen-Paap (2006) doi:10.1016/j.jeconom.2005.02.011 iterative rank test for initial rank estimation when target_level_kp2006_rank_test \( > 0 \), with an adjustment to level \( = \frac{\text{target}_\text{level}_\text{kp2006_rank_test}}{n_\text{factors}} \). When \( \text{target}_\text{level}_\text{kp2006_rank_test} \leq 0 \), the number of singular values above \( n_\text{observations}^{1/4} \) is used instead. It presumes that the number of factors is less than the number of returns (\( n_\text{factors} < n_\text{returns} \)). All the details can be found in Chen-Fang (2019) doi:10.3982/QE1139.
Usage

ChenFang2019BetaRankTest(
    returns,
    factors,
    n_bootstrap = 500,
    target_level_kp2006_rank_test = 0.05,
    check_arguments = TRUE
)

Arguments

returns Matrix of test asset excess returns with dimensions n_observations x n_returns.
factors Matrix of risk factors with dimensions n_observations x n_factors.
n_bootstrap The number of bootstrap samples to use in the Chen-Fang (2019) test. Defaults to 500 if not specified.
target_level_kp2006_rank_test The significance level for the Kleibergen-Paap (2006) rank test used for initial rank estimation. If set above 0, it indicates the level for this estimation within the Chen-Fang (2019) rank test. If set at 0 or negative, the initial rank estimator defaults to the count of singular values exceeding n_observations^*(-1/4). The default value is 0.05 to account for multiple testing.
check_arguments Logical flag to determine if input arguments should be checked for validity. Default is TRUE.

Value

A list containing the Chen-Fang (2019) rank statistic and the associated p-value.

Examples

# import package data on 6 risk factors and 42 test asset excess returns
factors = intrinsicFRP::factors[, -1]
returns = intrinsicFRP::returns[, -1]

# compute the model identification test
hj_test = ChenFang2019BetaRankTest(returns, factors)

factors

Factors - monthly observations from 01/1970 to 12/2021

Description

Monthly observations from 01/1970 to 12/2021 of the Fama-French 5 factors and the momentum factor.
Usage

factors

Format

factors:
A data frame with 624 rows and 7 columns:

Date  Date in yyyymm format
...  Factor observations

Source

https://mba.tuck.dartmouth.edu/pages/faculty/ken.french/data_library.html

FRP

Factor risk premia.

Description

Computes the Fama-MachBeth (1973) doi:10.1086/260061 factor risk premia: $\text{FMFRP} = (\beta' \cdot \beta)^{-1} \cdot \beta'^{\prime} \cdot \beta_{\text{Var}}$ where $\beta = \text{Cov}[R, F] \cdot V[F]^{-1}$ or the misspecification-robust factor risk premia of Kan-Robotti-Shanken (2013) doi:10.1111/jofi.12035: $\text{KRSFRP} = (\beta' \cdot V[R]^{-1} \cdot \beta' \cdot \beta_{\text{Var}})_{\text{Var}}^{-1} \cdot \beta_{\text{Var}} \cdot E[R]$, from data on factors $F$ and test asset excess returns $R$. These notions of factor risk premia are by construction the negative covariance of factors $F$ with candidate SDF $M = 1 - d' \cdot (F - E[F])$, where SDF coefficients $d$ are obtained by minimizing pricing errors: $\arg \min_{d} (E[R] - \text{Cov}[R,F] \cdot d)^{\prime} \cdot (E[R] - \text{Cov}[R,F] \cdot d)$ and $\arg \min_{d} (E[R] - \text{Cov}[R,F] \cdot d)^{\prime} \cdot V[R]^{-1} \cdot (E[R] - \text{Cov}[R,F] \cdot d)$, respectively. Optionally computes the corresponding heteroskedasticity and autocorrelation robust standard errors using the Newey-West (1994) doi:10.2307/2297912 plug-in procedure to select the number of relevant lags, i.e., $n_{\text{lags}} = 4 \cdot (n_{\text{observations}}/100)^{(2/9)}$. For the standard error computations, the function allows to internally pre-whiten the series by fitting a VAR(1), i.e., a vector autoregressive model of order 1. All the details can be found in Kan-Robotti-Shanken (2013) doi:10.1111/jofi.12035.

Usage

FRP(
    returns,
    factors,
    misspecification_robust = TRUE,
    include_standard_errors = FALSE,
    hac_prewhite = FALSE,
    target_level_gkr2014_screening = 0,
    check_arguments = TRUE
)
Arguments

returns A n_observations x n_returns-dimensional matrix of test asset excess returns.
factors A n_observations x n_factors-dimensional matrix of factors.

misspecification_robust

A boolean: TRUE for the "misspecification-robust" Kan-Robotti-Shanken (2013) GLS approach using the inverse covariance matrix of returns; FALSE for standard Fama-MacBeth risk premia. Default is TRUE.

include_standard_errors

A boolean: TRUE if you want to compute the factor risk premia HAC standard errors; FALSE otherwise. Default is FALSE.

hac_prewhtie

A boolean indicating if the series needs pre-whitening by fitting an AR(1) in the internal heteroskedasticity and autocorrelation robust covariance (HAC) estimation. Default is false.

target_level_gkr2014_screening

A number indicating the target level of the tests underlying the factor screening procedure in Gospodinov-Kan-Robotti (2014). If it is zero, then no factor screening procedure is implemented. Otherwise, it implements an iterative screening procedure based on the sequential removal of factors associated with the smallest insignificant t-test of a nonzero SDF coefficient. The threshold for the absolute t-test is target_level_gkr2014_screening / n_factors, where n_factors indicate the number of factors in the model at the current iteration. Default is 0., i.e., no factor screening.

check_arguments

A boolean: TRUE for internal check of all function arguments; FALSE otherwise. Default is TRUE.

Value

A list containing n_factors-dimensional vector of factor risk premia in "risk_premia"; if include_standard_errors = TRUE, then it further includes n_factors-dimensional vector of factor risk premia standard errors in "standard_errors"; if target_level_gkr2014_screening >= 0, it further includes the indices of the selected factors in selected_factor_indices.

Examples

# import package data on 6 risk factors and 42 test asset excess returns
factors = intrinsicFRP::factors[,,-1]
returns = intrinsicFRP::returns[,,-1]

# compute KRS factor risk premia and their standard errors
frp = FRP(returns, factors, include_standard_errors = TRUE)
GKRFactorScreening

Factor screening procedure of Gospodinov-Kan-Robotti (2014)

Description

Performs the factor screening procedure of Gospodinov-Kan-Robotti (2014) doi:10.2139/ssrn.2579821, which is an iterative model screening procedure based on the sequential removal of factors associated with the smallest insignificant t-test of a nonzero misspecification-robust SDF coefficient. The significance threshold for the absolute t-test is set to \( \frac{\text{target\_level}}{n\_\text{factors}} \), where \( n\_\text{factors} \) indicates the number of factors in the model at the current iteration; that is, it takes care of the multiple testing problem via a conservative Bonferroni correction. Standard errors are computed with the heteroskedasticity and autocorrelation using the Newey-West (1994) doi:10.2307/2297912 estimator, where the number of lags is selected using the Newey-West plug-in procedure: \( n\_\text{lags} = 4 \times \left( \frac{n\_\text{observations}}{100} \right)^{2/9} \). For the standard error computations, the function allows to internally pre-whiten the series by fitting a VAR(1), i.e., a vector autoregressive model of order 1. All the details can be found in Gospodinov-Kan-Robotti (2014) doi:10.2139/ssrn.2579821.

Usage

GKRFactorScreening(
  returns,
  factors,
  target_level = 0.05,
  hac_prewhite = FALSE,
  check_arguments = TRUE
)

Arguments

returns n_observations x n_returns-dimensional matrix of test asset excess returns.
factors n_observations x n_factors-dimensional matrix of risk factors.
target_level Number specifying the target significance threshold for the tests underlying the GKR factor screening procedure. To account for the multiple testing problem, the significance threshold for the absolute t-test is given by \( \frac{\text{target\_level\_gkr2014\_screening}}{n\_\text{factors}} \), where \( n\_\text{factors} \) indicate the number of factors in the model at the current iteration. Default is 0.05.
hac_prewhite A boolean indicating if the series needs prewhitening by fitting an AR(1) in the internal heteroskedasticity and autocorrelation robust covariance (HAC) estimation. Default is false.
check_arguments boolean TRUE for internal check of all function arguments; FALSE otherwise. Default is TRUE.
**Value**

A list containing the selected GKR SDF coefficients in `SDF_coefficients`, their standard errors in `standard_errors`, t-statistics in `t_statistics` and indices in the columns of the factor matrix `factors` supplied by the user in `selected_factor_indices`.

**Examples**

```r
# import package data on 6 risk factors and 42 test asset excess returns
factors = intrinsicFRP::factors[,,-1]
returns = intrinsicFRP::returns[,,-1]

# Perform the GKR factor screening procedure
screen = GKRFactorScreening(returns, factors)
```

---

**HACcovariance**  
*Heteroskedasticity and Autocorrelation robust covariance estimator*

**Description**

This function estimates the long-run covariance matrix of a multivariate centred time series accounting for heteroskedasticity and autocorrelation using the Newey-West (1994) doi:10.2307/2297912 estimator. The number is selected using the Newey-West plug-in procedure, where \( n_{lags} = 4 \times (n_{observations}/100)^{2/9} \). The function allows to internally prewhiten the series by fitting a VAR(1). All the details can be found in Newey-West (1994) doi:10.2307/2297912.

**Usage**

```r
HACcovariance(series, prewhite = FALSE, check_arguments = TRUE)
```

**Arguments**

- `series`: A matrix (or vector) of data where each column is a time series.
- `prewhite`: A boolean indicating if the series needs prewhitening by fitting an AR(1). Default is FALSE.
- `check_arguments`: A boolean TRUE for internal check of all function arguments; FALSE otherwise. Default is TRUE.

**Value**

A symmetric matrix (or a scalar if only one column series is provided) representing the estimated HAC covariance.
Examples

# Import package data on 6 risk factors and 42 test asset excess returns
returns = intrinsicFRP::returns[, -1]
factors = intrinsicFRP::factors[, -1]

# Fit a linear model of returns on factors
fit = stats::lm(returns ~ factors)

# Extract residuals from the model
residuals = stats::residuals(fit)

# Compute the HAC covariance of the residuals
hac_covariance = HACcovariance(residuals)

# Compute the HAC covariance of the residuals imposing prewhitening
hac_covariance_pw = HACcovariance(residuals, prewhite = TRUE)

HJMisspecificationDistance

Compute the HJ asset pricing model misspecification distance.

Description

Computes the Kan-Robotti (2008) \(^{10.1016/j.jempfin.2008.03.003}\) squared model misspecification distance: \(\text{square\_distance} = \min_d (E[R] - \text{Cov}[R,F] \ast d)' \ast V[R]^{-1} \ast (E[R] - \text{Cov}[R,F] \ast d)\), where \(R\) denotes test asset excess returns and \(F\) risk factors, and computes the associated confidence interval. This model misspecification distance is a modification of the prominent Hansen-Jagannathan (1997) \(^{doi:10.1111/j.1540-6261.1997.tb04813.x}\) distance, adapted to the use of excess returns for the test asset, and a SDF that is a linear function of demeaned factors. Clearly, computation of the confidence interval is obtained by means of an asymptotic analysis under potentially misspecified models, i.e., without assuming correct model specification. Details can be found in Kan-Robotti (2008) \(^{10.1016/j.jempfin.2008.03.003}\).

Usage

HJMisspecificationDistance(
    returns,
    factors,
    ci_coverage = 0.95,
    hac_prewhite = FALSE,
    check_arguments = TRUE
)

Arguments

returns A \(n\_\text{observations} \times n\_\text{returns}\) matrix of test asset excess returns.
factors A \(n\_\text{observations} \times n\_\text{factors}\) matrix of risk factors.
ci_coverage  A number indicating the confidence interval coverage probability. Default is 0.95.

hac_prewhite  A boolean indicating if the series needs pre-whitening by fitting an AR(1) in the internal heteroskedasticity and autocorrelation robust covariance (HAC) estimation. Default is false.

check_arguments  A boolean: TRUE for internal check of all function arguments; FALSE otherwise. Default is TRUE.

Value

@return A list containing the squared misspecification-robust HJ distance in squared_distance, and the lower and upper confidence bounds in lower_bound and upper_bound, respectively.

Examples

# Import package data on 6 risk factors and 42 test asset excess returns
factors = intrinsicFRP::factors[,-1]
returns = intrinsicFRP::returns[,-1]

# Compute the HJ model misspecification distance
hj_test = HJMisspecificationDistance(returns, factors)
Arguments

returns A matrix of test asset excess returns with dimensions n_observations x n_returns.
factors A matrix of risk factors with dimensions n_observations x n_factors.
target_level A numeric value specifying the significance level for the test. For each hypothesis test H: rank(beta) = q, the significance level is adjusted to target_level / n_factors. The default is 0.05.
check_arguments Logical flag indicating whether to perform internal checks of the function’s arguments. Defaults to TRUE.

Value

A list containing estimates of the regression loading rank and the associated iterative Kleibergen-Paap 2006 beta rank statistics and p-values for each q.

Examples

# import package data on 15 risk factors and 42 test asset excess returns
factors = intrinsicFRP::factors[,,-1]
returns = intrinsicFRP::returns[,,-1]

# compute the model identification test
hj_test = ChenFang2019BetaRankTest(returns, factors)

OracleTFRP

Oracle tradable factor risk premia.

Description

Computes Oracle tradable factor risk premia of Quaini-Trojani-Yuan (2023) doi:10.2139/ssrn.4574683 from data on K factors \( F = \{ F_1, \ldots, F_K \} \) and test asset excess returns \( R \): 
\[
\text{OTFRP} = \text{argmin}_x \| TFRP - x \|_2^2 + \tau \| \sum_{k=1}^K w_k \|_2^2
\]
where \( TFRP \) is the tradable factor risk premia estimator, \( \tau > 0 \) is a penalty parameter, and the Oracle weights are given by \( w_k = 1 / \| \text{corr}[F_k, R] \|_2^2 \). This estimator is called "Oracle" in the sense that the probability that the index set of its nonzero estimated risk premia equals the index set of the true strong factors tends to 1 (Oracle selection), and that on the strong factors, the estimator reaches the optimal asymptotic Normal distribution. Here, strong factors are those that have a nonzero population marginal correlation with asset excess returns. Tuning of the penalty parameter \( \tau \) is performed via Generalized Cross Validation (GCV), Cross Validation (CV) or Rolling Validation (RV). GCV tunes parameter \( \tau \) by minimizing the criterium: 
\[
\| \text{PE}(\tau) \|_2^2 / (1 - \text{df}(\tau)/T)^2
\]
where \( \text{PE}(\tau) = \text{E}[R] - \text{beta}_{S(\tau)} \times \text{OTFRP}(\tau) \) are the pricing errors of the model for given tuning parameter \( \tau \), with \( S(\tau) \) being the index set of the nonzero Oracle TFRP computed with tuning parameter \( \tau \), and \( \text{beta}_{S(\tau)} = \text{Cov}[R, F_{S(\tau)}] * \text{OTFRP}(\tau) \) the regression coefficients of the test assets excess returns on the factor mimicking portfolios, and \( \text{df}(\tau) = |S(\tau)| \) are the degrees of freedom of the model, given by the number of nonzero Oracle TFRP. CV and RV, instead, choose the value of \( \tau \) that minimize the criterium:
**OracleTFRP**

\[
\text{PE}(\tau) \ast V[\text{PE}(\tau)]^{-1} \text{PE}(\tau)
\]
where \(V[\text{PE}(\tau)]\) is the diagonal matrix collecting the marginal variances of pricing errors \(\text{PE}(\tau)\), and each of these components are aggregated over k-fold cross-validated data or over rolling windows of data, respectively. Oracle weights can be based on the correlation between factors and returns (suggested approach), on the regression coefficients of returns on factors or on the first-step tradable risk premia estimator. Optionally computes the corresponding heteroskedasticity and autocorrelation robust standard errors using the Newey-West (1994) \(\text{doi:10.2307/2297912}\) plug-in procedure to select the number of relevant lags, i.e., \(n_{\text{lags}} = 4 \times (n_{\text{observations}}/100)^{(2/9)}\). For the standard error computations, the function allows to internally pre-whiten the series by fitting a VAR(1), i.e., a vector autoregressive model of order 1. All details are found in Quaini-Trojani-Yuan (2023) \(\text{doi:10.2139/ssrn.4574683}\).

**Usage**

```r
OracleTFRP(
  returns,
  factors,
  penalty_parameters,
  weighting_type = "c",
  tuning_type = "g",
  one_stddev_rule = TRUE,
  gcv_scaling_n_assets = FALSE,
  gcv_identification_check = FALSE,
  target_level_kp2006_rank_test = 0.05,
  n_folds = 5,
  n_train_observations = 120,
  n_test_observations = 12,
  roll_shift = 12,
  relaxed = FALSE,
  include_standard_errors = FALSE,
  hac_prewhite = FALSE,
  plot_score = TRUE,
  check_arguments = TRUE
)
```

**Arguments**

- **returns**: A \(n_{\text{observations}} \times n_{\text{returns}}\)-dimensional matrix of test asset excess returns.
- **factors**: A \(n_{\text{observations}} \times n_{\text{factors}}\)-dimensional matrix of factors.
- **penalty_parameters**: A \(n_{\text{parameters}}\)-dimensional vector of penalty parameter values from smallest to largest.
- **weighting_type**: A character specifying the type of adaptive weights: based on the correlation between factors and returns 'c'; based on the regression coefficients of returns on factors 'b'; based on the first-step tradable risk premia estimator 'a'; otherwise a vector of ones (any other character). Default is 'c'.
- **tuning_type**: A character indicating the parameter tuning type: 'g' for generalized cross validation; 'c' for K-fold cross validation; 'r' for rolling validation. Default is
'g'.

one_stddev_rule
A boolean: TRUE for picking the most parsimonious model whose score is not higher than one standard error above the score of the best model; FALSE for picking the best model. Default is TRUE.

gcv_scaling_n_assets
(only relevant for tuning_type = 'g') A boolean: TRUE for sqrt(n_assets) scaling (sqrt(n_assets) / n_observations); FALSE otherwise (1 / n_observations). Default is FALSE.

gcv_identification_check
(only relevant for tuning_type = 'g') A boolean: TRUE for a loose check for model identification; FALSE otherwise. Default is FALSE.

target_level_kp2006_rank_test
(only relevant for tuning_type = 'g' and if gcv_identification_check is TRUE) A number indicating the level of the Kleibergen Paap 2006 rank test. If it is strictly greater than zero, then the iterative Kleibergen Paap 2006 rank test at level = target_level_kp2006_rank_test / n_factors (where division by the number of factors is performed as a Bonferroni correction for multiple testing) is used to compute an initial estimator of the rank of the factor loadings in the Chen Fang 2019 rank test. Otherwise, the initial rank estimator is taken to be the number of singular values above n_observations^(-1/4). Default is 0.05.

n_folds
(only relevant for tuning_type = 'c') An integer indicating the number of k-fold for cross validation. Default is 5.

n_train_observations
(only relevant for tuning_type = 'r') The number of observations in the rolling training set. Default is 120.

n_test_observations
(only relevant for tuning_type = 'r') The number of observations in the test set. Default is 12.

roll_shift
(only relevant for tuning_type = 'r') The number of observation shift when moving from the rolling window to the next one. Default is 12.

relaxed
A boolean: TRUE if you want to compute a post-selection unpenalized tradable factor risk premia to remove the bias due to shrinkage; FALSE otherwise. Default is FALSE.

include_standard_errors
A boolean: TRUE if you want to compute the adaptive tradable factor risk premia HAC standard errors; FALSE otherwise. Default is FALSE.

hac_prewight
A boolean indicating if the series needs prewhitening by fitting an AR(1) in the internal heteroskedasticity and autocorrelation robust covariance (HAC) estimation. Default is false.

plot_score
A boolean: TRUE for plotting the model score; FALSE otherwise. Default is TRUE.

check_arguments
A boolean: TRUE for internal check of all function arguments; FALSE otherwise. Default is TRUE.
Value

A list containing the `n_factors`-dimensional vector of adaptive tradable factor risk premia in "risk_premia"; the optimal penalty parameter value in "penalty_parameter"; the model score for each penalty parameter value in "model_score"; if `include_standard_errors = TRUE`, then it further includes `n_factors`-dimensional vector of tradable factor risk premia standard errors in "standard_errors".

Examples

```r
# import package data on 6 risk factors and 42 test asset excess returns
defactors = intrinsicFRP::factors[,,-1]
dreturns = intrinsicFRP::returns[,,-1]

penalty_parameters = seq(0., 1., length.out = 100)

# compute optimal adaptive tradable factor risk premia and their standard errors
oracle_tfrp = OracleTFRP(
dreturns,
defactors,
penalty_parameters,
include_standard_errors = TRUE
)
```

returns

<table>
<thead>
<tr>
<th>returns</th>
<th>Test Asset Excess Returns - monthly observations from 01/1970 to 12/2021</th>
</tr>
</thead>
</table>

Description


Usage

returns

Format

returns:
A data frame with 624 rows and 43 columns:

- **Date** Date in yyyymm format
- ... Asset excess returns

Source

https://mba.tuck.dartmouth.edu/pages/faculty/ken.french/data_library.html
TFRP

Tradable factor risk premia.

Description

Computes tradable factor risk premia from data on factors $F$ and test asset excess returns $R$: $TFRP = \text{Cov}[F, R] \times \text{Var}[R]^{-1} \times \text{E}[R]$; which are by construction the negative covariance of factors $F$ with the SDF projection on asset returns, i.e., the minimum variance SDF. Optionally computes the corresponding heteroskedasticity and autocorrelation robust standard errors using the Newey-West (1994) doi:10.2307/2297912 plug-in procedure to select the number of relevant lags, i.e., $n_{lags} = 4 \times (n_{observations}/100)^{(2/9)}$. For the standard error computations, the function allows to internally pre-whiten the series by fitting a VAR(1), i.e., a vector autoregressive model of order 1. All details are found in Quaini-Trojani-Yuan (2023) doi:10.2139/ssrn.4574683.

Usage

```r
TFRP(
  returns,  
  factors,  
  include_standard_errors = FALSE,  
  hac_prewhite = FALSE,  
  check_arguments = TRUE
)
```

Arguments

- `returns`: A $n_{observations} \times n_{returns}$-dimensional matrix of test asset excess returns.
- `factors`: A $n_{observations} \times n_{factors}$-dimensional matrix of factors.
- `include_standard_errors`: A boolean: TRUE if you want to compute the tradable factor risk premia HAC standard errors; FALSE otherwise. Default is FALSE.
- `hac_prewhite`: A boolean indicating if the series needs prewhitening by fitting an AR(1) in the internal heteroskedasticity and autocorrelation robust covariance (HAC) estimation. Default is false.
- `check_arguments`: A boolean: TRUE for internal check of all function arguments; FALSE otherwise. Default is TRUE.

Value

A list containing $n_{factors}$-dimensional vector of tradable factor risk premia in "risk_premia"; if `include_standard_errors=TRUE`, then it further includes $n_{factors}$-dimensional vector of tradable factor risk premia standard errors in "standard_errors".
Examples

# import package data on 6 risk factors and 42 test asset excess returns
factors = intrinsicFRP::factors[, -1]
returns = intrinsicFRP::returns[, -1]

# compute tradable factor risk premia and their standard errors
tfrp = TFRP(returns, factors, include_standard_errors = TRUE)
Index

* datasets
  factors, 3
  returns, 13

ChenFang2019BetaRankTest, 2

factors, 3
FRP, 4

GKRFactorScreening, 6

HACcovariance, 7
HJMisspecificationDistance, 8

IterativeKleibergenPaap2006BetaRankTest, 9

OracleTFRP, 10

returns, 13
TFRP, 14