

# Package ‘esreg’

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**Type** Package

**Title** Joint Quantile and Expected Shortfall Regression

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**Description**

Simultaneous modeling of the quantile and the expected shortfall of a response variable given a set of covariates, see Dimitriadis and Bayer (2019) <doi:10.1214/19-EJS1560>.

**License** GPL-3

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esreg

*Joint Quantile and Expected Shortfall Regression***Description**

Estimates a joint linear regression model for the pair (VaR, ES):

$$Q_{\alpha}(Y|Xq) = Xq'\beta_q$$

$$ES_{\alpha}(Y|Xe) = Xe'\beta_e$$

**Usage**

```
esreg(...)
```

```
## S3 method for class 'formula'
```

```
esreg(
  formula,
  data = parent.frame(),
  alpha,
  g1 = 2L,
  g2 = 1L,
  early_stopping = 10,
  ...
)
```

```
## Default S3 method:
```

```
esreg(xq, xe, y, alpha, g1 = 2L, g2 = 1L, early_stopping = 10, ...)
```

**Arguments**

...	Further arguments (does not apply here)
formula	Formula: $y \sim x_1 + x_2 \dots   x_1 + x_2 \dots$ where the first part after the response variable specifies the quantile equation and the second the expected shortfall part. If only one set of regressors is provided it is used for both model specifications.
data	data.frame that holds the variables
alpha	Probability level
g1	1, 2 (see <a href="#">G1_fun</a> , <a href="#">G1_prime_fun</a> ), defaults to 1
g2	1, 2, 3, 4, 5 (see <a href="#">G2_curly_fun</a> , <a href="#">G2_fun</a> , <a href="#">G2_prime_fun</a> ). defaults to 2
early_stopping	Stop the iterated local search if there is no improvement in early_stopping steps.
xq	Explanatory variables for the quantile regression equation
xe	Explanatory variables for the expected shortfall regression equation
y	Response vector

**Value**

An esreg object

**References**

[A Joint Quantile and Expected Shortfall Regression Framework](#)

**See Also**

[vcov.esreg](#) for covariance estimation

**Examples**

```
# Simulate data (DGP-(2) in the linked paper)
set.seed(0)
x <- rchisq(1000, df=1)
y <- -x + (1 + 0.5 * x) * rnorm(1000)

# True quantile and expected shortfall regression parameters (for alpha=0.025)
alpha=0.025
true_pars <- c(-1.959964, -1.979982, -2.337803, -2.168901)

# Estimate the model using the standard settings
fit <- esreg(y ~ x, alpha=alpha)

# Compare the different variance-covariance estimators
cov1 <- vcov(object=fit, sparsity="iid", sigma_est="ind")
cov2 <- vcov(object=fit, sparsity="nid", sigma_est="scl_N")
cov3 <- vcov(object=fit, sparsity="nid", sigma_est="scl_sp")

print("Comparison of the variance-covariance estimators")
print(cbind(Truth=true_pars,
            Estimate=coef(fit),
            SE_iid_ind=sqrt(diag(cov1)),
            SE_nid_N=sqrt(diag(cov2)),
            SE_nid_sp=sqrt(diag(cov3))))

# Compares estimates using different G2 functions
fit1 <- esreg(y ~ x, alpha=alpha, g2=1)
fit2 <- esreg(y ~ x, alpha=alpha, g2=2)
fit3 <- esreg(y ~ x, alpha=alpha, g2=3)
fit4 <- esreg(y ~ x, alpha=alpha, g2=4)
fit5 <- esreg(y ~ x, alpha=alpha, g2=5)
fits <- sapply(list(fit1, fit2, fit3, fit4, fit5), coef)
colnames(fits) <- sapply(1:5, function(i) esreg:::G_function_names(1, i)[2])
print("Comparison of the five G2 functions")
print(rbind(Truth=true_pars, t(fits)))

# Usage of different covariates
x <- rchisq(1000, df=1)
noise <- rnorm(1000)
y <- -x + (1 + 0.5 * x) * rnorm(1000)
```

```
fit <- esreg(y ~ x | x + noise, alpha=0.025)
print("Using different covariates for VaR and ES")
print(summary(fit))
```

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 esr\_loss

*Joint Loss Function*


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### Description

Computes the joint (VaR, ES) loss

### Usage

```
esr_loss(r, q, e, alpha, g1 = 2L, g2 = 1L, return_mean = TRUE)
```

### Arguments

r	Vector of returns
q	Vector of quantiles
e	Vector of expected shortfalls
alpha	Probability level
g1	1, 2, see <a href="#">G1_fun</a>
g2	1, 2, 3, 4, 5, see <a href="#">G2_curly_fun</a> , <a href="#">G2_fun</a>
return_mean	If TRUE returns the average tick loss, else the individual values

### References

Fissler and Ziegel (2016)

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 estfun.esreg

*Estimating function*


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### Description

This function matches the estfun function of the sandwich package and returns the estimating functions for the fitted model. It can for instance be used for an OPG estimator of the sigma matrix. For esreg, the dimension of the estimating functions is  $n \times (k_q + k_e)$ .

### Usage

```
estfun.esreg(x, ...)
```

### Arguments

x	An <a href="#">esreg</a> object
...	Further arguments (does not apply here)

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lambda_matrix	<i>Lambda Matrix</i>
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**Description**

Estimate the lambda matrix.

**Usage**

```
lambda_matrix(object, sparsity, bandwidth_estimator, misspec)
```

**Arguments**

object	An esreg object
sparsity	The estimator to be used for the sparsity in $\Lambda$ , see <a href="#">density_quantile_function</a> <ul style="list-style-type: none"> <li>• iid - Piecewise linear interpolation of the distribution</li> <li>• nid - Hendricks and Koenker sandwich</li> </ul>
bandwidth_estimator	The bandwidth estimator to be used for the iid and nid sparsity estimator, see <a href="#">density_quantile_function</a> <ul style="list-style-type: none"> <li>• Bofinger</li> <li>• Chamberlain</li> <li>• Hall-Sheather</li> </ul>
misspec	if TRUE, the estimator accounts for potential misspecification in the model

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sigma_matrix	<i>Sigma Matrix</i>
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**Description**

Estimate the sigma matrix.

**Usage**

```
sigma_matrix(object, sigma_est, misspec)
```

**Arguments**

object	An esreg object
sigma_est	The estimator to be used for $\Sigma$ , see <a href="#">conditional_truncated_variance</a> <ul style="list-style-type: none"> <li>• ind - Variance over all negative residuals</li> <li>• scl_N - Scaling with the normal distribution</li> <li>• scl_sp - Scaling with the kernel density function</li> </ul>
misspec	if TRUE, the estimator accounts for potential misspecification in the model

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vcov.esreg

*Covariance Estimation*


---

### Description

Estimate the variance-covariance matrix of the joint (VaR, ES) estimator

### Usage

```
## S3 method for class 'esreg'
vcov(object, method = "asymptotic", ...)
```

### Arguments

object	An <a href="#">esreg</a> object
method	For asymptotic use <a href="#">vcovA</a> , for boot use <a href="#">vcovB</a>
...	All possible values which can be passed to <a href="#">vcovA</a> and <a href="#">vcovB</a>

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vcovA

*Asymptotic Covariance Estimation*


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### Description

Estimate the variance-covariance matrix of the joint (VaR, ES) estimator by the sandwich formula:

$$\lambda^{-1}\Sigma\lambda^{-1}$$

Several estimators are available for both matrices and the default options are selected to take into account possible misspecifications in the underlying data.

### Usage

```
vcovA(
  object,
  sigma_est = "scl_sp",
  sparsity = "nid",
  misspec = TRUE,
  bandwidth_estimator = "Hall-Sheather"
)
```

**Arguments**

object	An esreg object
sigma_est	The estimator to be used for $\Sigma$ , see <a href="#">conditional_truncated_variance</a> <ul style="list-style-type: none"> <li>• ind - Variance over all negative residuals</li> <li>• scl_N - Scaling with the normal distribution</li> <li>• scl_sp - Scaling with the kernel density function</li> </ul>
sparsity	The estimator to be used for the sparsity in $\Lambda$ , see <a href="#">density_quantile_function</a> <ul style="list-style-type: none"> <li>• iid - Piecewise linear interpolation of the distribution</li> <li>• nid - Hendricks and Koenker sandwich</li> </ul>
misspec	if TRUE, the estimator accounts for potential misspecification in the model
bandwidth_estimator	The bandwidth estimator to be used for the iid and nid sparsity estimator, see <a href="#">density_quantile_function</a> <ul style="list-style-type: none"> <li>• Bofinger</li> <li>• Chamberlain</li> <li>• Hall-Sheather</li> </ul>

vcovB

*Bootstrap Covariance Estimation***Description**

Estimate the variance-covariance matrix of the joint (VaR, ES) estimator using the bootstrap.

**Usage**

```
vcovB(object, bootstrap_method = "iid", B = 1000)
```

**Arguments**

object	An esreg object
bootstrap_method	The bootstrap sampling scheme to be used <ul style="list-style-type: none"> <li>• iid - The iid bootstrap of Efron (1979)</li> </ul>
B	The number of bootstrap iterations

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