

Package ‘JumpDiffSim’

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Type Package

Title Jump Diffusion Simulation and Calibration for Merton and Kou Models

Version 0.1.0

Description Implements the Merton (1976) <[doi:10.1016/0304-405X\(76\)90022-2](https://doi.org/10.1016/0304-405X(76)90022-2)> and Kou (2002) <[doi:10.1287/mnsc.48.8.1086.166](https://doi.org/10.1287/mnsc.48.8.1086.166)> jump-diffusion models through a unified S4 object-oriented interface. Provides exact compound-Poisson asset price simulation, maximum likelihood parameter estimation with Hessian-based standard errors, Wald-type confidence intervals, European option pricing via the Merton analytic series expansion, and publication-quality diagnostic plots. All functionality operates entirely offline without market data dependencies.

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Author Kennedy Titus Kayaki [aut, cre],
Dohyun Oh [aut],
Ju Seong Hyeon [aut],

Lee Se Eun [aut],
 Choi Jiwoo [aut],
 Yuri Shin [aut]

Maintainer Kennedy Titus Kayaki <kennedy_2244@yu.ac.kr>

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diagnosticPlots	<i>Diagnostic Plots for a JDSimResult Object</i>
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Description

Creates three diagnostic plots for a [JDSimResult](#) object: a simulated path fan chart, a histogram of log-returns with a normal density overlay, and the autocorrelation function of squared log-returns.

Usage

```
diagnosticPlots(object)
```

Arguments

object A [JDSimResult](#) object.

Value

A named list of three ggplot objects:

- `fan_chart`: simulated path quantile fan chart.
- `density`: histogram of log-returns with a normal overlay.
- `acf_sq`: autocorrelation of squared log-returns with 95\

Examples

```
m <- MertonModel()
sim <- simulateMerton(m, n = 50, T_ = 1, steps = 100)
plts <- diagnosticPlots(sim)
print(plts$fan_chart)
print(plts$density)
print(plts$acf_sq)
```

fit

Fit Model to Log>Returns via MLE

Description

Fit Model to Log>Returns via MLE

Usage

```
fit(object, log_returns, ...)
```

Arguments

<code>object</code>	A JumpDiffModel object.
<code>log_returns</code>	Numeric vector of observed log returns.
<code>...</code>	Passed to optim .

Value

A [JDFitResult](#) object.

`fitMerton`*Fit Merton Jump-Diffusion Model via MLE*

Description

Maximises the log-likelihood of the Merton (1976) model using L-BFGS-B optimisation. Returns a [JDFitResult](#) object containing parameter estimates, standard errors, and convergence info.

Usage

```
fitMerton(  
  log_returns,  
  start = c(mu = 0.05, sigma = 0.2, lambda = 1, mu_j = -0.1, sigma_j = 0.15),  
  dt = 1/252,  
  N_max = 50L,  
  verbose = FALSE  
)
```

Arguments

<code>log_returns</code>	Numeric vector of observed log asset returns.
<code>start</code>	Named numeric vector of starting values. Defaults to <code>c(mu=0.05, sigma=0.20, lambda=1, mu_j=-0.10, sigma_j=0.15)</code> .
<code>dt</code>	Numeric. Time step length (default 1/252).
<code>N_max</code>	Integer. Mixture truncation (default 50).
<code>verbose</code>	Logical. Print progress? (default FALSE).

Value

A [JDFitResult](#) object.

Examples

```
ret <- jdSampleData("merton", n = 500, seed = 42)  
fit <- fitMerton(ret, verbose = TRUE)  
print(fit)  
confint(fit)
```

JDFitResult-class *JDFitResult: MLE Estimation Output Class*

Description

JDFitResult: MLE Estimation Output Class

Usage

```
## S4 method for signature 'JDFitResult'  
show(object)
```

```
## S4 method for signature 'JDFitResult'  
confint(object, parm, level = 0.95, ...)
```

Arguments

object	A JDFitResult object.
parm	Ignored (all parameters returned).
level	Confidence level (default 0.95).
...	Unused.

Methods (by generic)

- `confint(JDFitResult)`: Wald-type 95\

Slots

estimates Named numeric. Parameter estimates.
se Named numeric. Standard errors.
loglik Numeric. Log-likelihood at optimum.
converged Logical. Did optimisation converge?
model_type Character. Model name.

 jdSampleData

Generate Synthetic Log>Returns from a Jump-Diffusion Model

Description

Convenience function for generating reproducible synthetic log-returns for use in examples, tests, and vignettes. All package examples and tests use this function to avoid any dependency on live market data.

Usage

```
jdSampleData(
  model = "merton",
  n = 500,
  mu = 0.05,
  sigma = 0.2,
  lambda = 1,
  mu_j = -0.1,
  sigma_j = 0.15,
  dt = 1/252,
  seed = 42L
)
```

Arguments

model	Character. Model type: "merton" (default).
n	Integer. Number of log-returns to generate (default 500).
mu	Numeric. Drift (default 0.05).
sigma	Positive numeric. Diffusion vol (default 0.20).
lambda	Non-negative numeric. Jump intensity (default 1).
mu_j	Numeric. Mean log-jump (default -0.10).
sigma_j	Positive numeric. Std dev of log-jumps (default 0.15).
dt	Numeric. Time step (default 1/252).
seed	Integer. Random seed (default 42).

Value

Numeric vector of n log-returns.

Examples

```
ret <- jdSampleData("merton", n = 200, seed = 42)
head(ret)
hist(ret, breaks = 40, main = "Synthetic Merton Returns")
```

JDSimResult-class *JDSimResult: Simulation Output Class*

Description

JDSimResult: Simulation Output Class

Slots

paths Matrix. Simulated price paths (n x steps+1).
times Numeric vector. Time grid.
params List. Model parameters used in simulation.
model_type Character. Model name.

JumpDiffModel-class *JumpDiffModel: Virtual Base Class for Jump-Diffusion Models*

Description

Abstract base class. Do not instantiate directly. Concrete subclasses: [MertonModel](#).

Slots

mu Numeric. Drift parameter (annualised).
sigma Positive numeric. Diffusion volatility.
lambda Non-negative numeric. Jump intensity (jumps per year).

jumpMoments *Theoretical Moments of the Log-Return Distribution*

Description

Theoretical Moments of the Log-Return Distribution

Usage

jumpMoments(object)

Arguments

object A [JumpDiffModel](#) object.

Value

Named numeric vector: mean, variance, skewness, kurtosis.

jumpMoments, MertonModel-method

Theoretical Moments of the Merton Jump-Diffusion Log-Return

Description

Returns the theoretical mean, variance, skewness, and excess kurtosis of the log-return distribution under the Merton (1976) model.

Usage

```
## S4 method for signature 'MertonModel'
jumpMoments(object)
```

Arguments

object A [MertonModel](#) object.

Value

Named numeric vector with elements mean, variance, skewness, kurtosis.

Examples

```
m <- MertonModel(mu = 0.05, sigma = 0.20, lambda = 1,
                 mu_j = -0.10, sigma_j = 0.15)
jumpMoments(m)
```

loglik

Compute Negative Log-Likelihood

Description

Compute Negative Log-Likelihood

Usage

```
loglik(object, log_returns, ...)
```

Arguments

object A [JumpDiffModel](#) object.
log_returns Numeric vector of log asset returns.
... Passed to methods.

Value

Scalar negative log-likelihood value.

mertonLogLik

Negative Log-Likelihood for the Merton Jump-Diffusion Model

Description

Evaluates the negative log-likelihood of observing `log_returns` under the Merton (1976) model. The density is approximated by a Gaussian mixture truncated at `N_max = 50` terms.

Usage

```
mertonLogLik(params, log_returns, dt = 1/252, N_max = 50L)
```

Arguments

<code>params</code>	Named numeric vector: <code>c(mu, sigma, lambda, mu_j, sigma_j)</code> .
<code>log_returns</code>	Numeric vector of observed log asset returns.
<code>dt</code>	Numeric. Length of each time step (default 1/252).
<code>N_max</code>	Integer. Number of mixture terms (default 50).

Value

Scalar. Negative log-likelihood. Returns `Inf` for invalid parameter values.

Examples

```
ret <- jdSampleData("merton", n = 200, seed = 42)
p <- c(mu = 0.05, sigma = 0.2, lambda = 1, mu_j = -0.1, sigma_j = 0.15)
mertonLogLik(p, ret)
```

MertonModel

Create a MertonModel Object

Description

Create a MertonModel Object

Usage

```
MertonModel(mu = 0.05, sigma = 0.2, lambda = 1, mu_j = -0.1, sigma_j = 0.15)
```

Arguments

mu	Numeric. Drift (default 0.05).
sigma	Positive numeric. Diffusion volatility (default 0.20).
lambda	Non-negative numeric. Jump intensity (default 1).
mu_j	Numeric. Mean log-jump size (default -0.10).
sigma_j	Positive numeric. Std dev of log-jumps (default 0.15).

Value

A validated [MertonModel](#) object.

Examples

```
m <- MertonModel(mu = 0.05, sigma = 0.20, lambda = 1,
                 mu_j = -0.10, sigma_j = 0.15)
show(m)
```

MertonModel-class

MertonModel: Merton (1976) Jump-Diffusion Model

Description

Extends [JumpDiffModel](#) with log-normal jump parameters.

Usage

```
## S4 method for signature 'MertonModel'
show(object)
```

Arguments

object A [MertonModel](#) object.

Slots

mu_j Numeric. Mean log-jump size.
sigma_j Positive numeric. Std dev of log-jump sizes.

References

Merton, R.C. (1976). Option pricing when underlying stock returns are discontinuous. *Journal of Financial Economics*, 3(1-2), 125-144.

priceEuropean

*Price a European Option under the Merton Jump-Diffusion Model***Description**

Computes the European call or put price under the Merton (1976) jump-diffusion model using the analytic series expansion. The price is expressed as a Poisson-weighted sum of Black-Scholes prices with jump-adjusted drift and volatility.

The formula is:

$$C = \sum_{n=0}^N \frac{e^{-\lambda'T} (\lambda'T)^n}{n!} \cdot BS(S, K, r_n, \sigma_n, T)$$

where $\lambda' = \lambda(1 + \bar{\mu}_J)$, $r_n = r - \lambda\bar{\mu}_J + n \log(1 + \bar{\mu}_J)/T$, and $\sigma_n^2 = \sigma^2 + n\sigma_J^2/T$.

Usage

```
priceEuropean(
  fit,
  S = 100,
  K = 100,
  r = 0.05,
  T_ = 1,
  type = "call",
  N_max = 50L
)
```

Arguments

fit	A JDFitResult object from fitMerton .
S	Positive numeric. Current asset price.
K	Positive numeric. Strike price.
r	Numeric. Continuously compounded risk-free rate.
T_	Positive numeric. Time to expiry in years.
type	Character. Either "call" or "put".
N_max	Integer. Number of series terms (default 50).

Value

A named list with elements:

price	Merton jump-diffusion option price.
bs_price	Black-Scholes benchmark price (no jumps).
jump_premium	Difference between Merton and BS price.
params	List of inputs and fitted parameters used.

References

Merton, R.C. (1976). Option pricing when underlying stock returns are discontinuous. *Journal of Financial Economics*, 3(1-2), 125-144.

Examples

```
ret <- jdSampleData("merton", n = 500, seed = 42)
fit <- fitMerton(ret)
price <- priceEuropean(fit, S = 100, K = 100,
                       r = 0.05, T_ = 1, type = "call")
print(price)
```

simulate

Simulate Asset Price Paths

Description

Simulate Asset Price Paths

Usage

```
simulate(object, n, T_, steps, seed = NULL, ...)
```

Arguments

object	A JumpDiffModel object.
n	Integer. Number of simulated paths.
T_	Positive numeric. Time horizon in years.
steps	Positive integer. Number of time steps.
seed	Optional integer seed for reproducibility.
...	Additional arguments passed to methods.

Value

A [JDSimResult](#) object.

simulateMerton	<i>Simulate Merton Jump-Diffusion Asset Paths</i>
----------------	---

Description

Generates n exact compound-Poisson asset price paths under the Merton (1976) jump-diffusion model. Simulation is exact in the sense that jump arrivals are drawn directly from the Poisson process rather than approximated via Euler discretisation.

Usage

```
simulateMerton(object, n = 100, T_ = 1, steps = 252, S0 = 1, seed = NULL, ...)
```

Arguments

object	A MertonModel object.
n	Integer. Number of paths to simulate.
T_	Positive numeric. Time horizon in years (default 1).
steps	Positive integer. Number of time steps (default 252).
S0	Numeric. Initial asset price (default 1).
seed	Optional integer. Random seed for reproducibility.
...	Unused.

Value

A [JDSimResult](#) object.

Examples

```
m <- MertonModel()
sim <- simulateMerton(m, n = 10, T_ = 1, steps = 252, seed = 42)
dim(sim@paths) # should be 200 x 253
```

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