

# Package ‘tweedie’

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**Title** Evaluation of Tweedie Exponential Family Models

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**Suggests** stabledist, statmod(>= 1.4.20)

**Description** Maximum likelihood computations for Tweedie families, including the series expansion (Dunn and Smyth, 2005; <doi:10.1007/s11222-005-4070-y>) and the Fourier inversion (Dunn and Smyth, 2008; <doi:10.1007/s11222-007-9039-6>), and related methods.

**License** GPL (>= 2)

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tweedie-package

*Tweedie Distributions*

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## Description

Functions for computing and fitting the Tweedie family of distributions

## Details

Package: tweedie  
Type: Package  
Version: 2.3.1  
Date: 2017-11-15  
License: GPL (>=2)

## Author(s)

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## References

Dunn, P. K. and Smyth, G. K. (2008). Evaluation of Tweedie exponential dispersion model densities by Fourier inversion. *Statistics and Computing*, **18**, 73–86. doi: [10.1007/s1122200790396](https://doi.org/10.1007/s1122200790396)

Dunn, Peter K and Smyth, Gordon K (2005). Series evaluation of Tweedie exponential dispersion model densities *Statistics and Computing*, **15**(4). 267–280. doi: [10.1007/s112220054070y](https://doi.org/10.1007/s112220054070y)

Dunn, Peter K and Smyth, Gordon K (2001). Tweedie family densities: methods of evaluation. *Proceedings of the 16th International Workshop on Statistical Modelling*, Odense, Denmark, 2–6 July

Jorgensen, B. (1987). Exponential dispersion models. *Journal of the Royal Statistical Society*, **B**, **49**, 127–162.

Jorgensen, B. (1997). *Theory of Dispersion Models*. Chapman and Hall, London.

Tweedie, M. C. K. (1984). An index which distinguishes between some important exponential families. *Statistics: Applications and New Directions. Proceedings of the Indian Statistical Institute Golden Jubilee International Conference* (Eds. J. K. Ghosh and J. Roy), pp. 579–604. Calcutta: Indian Statistical Institute.

## Examples

```
# Generate random numbers
set.seed(987654)
y <- rtweedie( 20, xi = 1.5, mu = 1, phi = 1)
# With Tweedie index xi between 1 and 2, this produces continuous
```

```

# data with exact zeros
x <- rnorm( length(y), 0, 1) # Unrelated predictor

# With exact zeros, Tweedie index xi must be between 1 and 2

# Fit the tweedie distribution; expect xi about 1.5
library(statmod)

xi.vec <- seq(1.1, 1.9, by = 0.5)
out <- tweedie.profile( y ~ 1, xi.vec = xi.vec, do.plot = TRUE, verbose = TRUE)

# Fit the glm
require(statmod) # Provides tweedie family functions
summary(glm( y ~ x, family = tweedie(var.power = out$xi.max, link.power = 0) ))

```

---

AICtweedie

*Tweedie Distributions*


---

### Description

The AIC for Tweedie glms

### Usage

```
AICtweedie( glm.obj, dispersion=NULL, k = 2, verbose=TRUE)
```

### Arguments

glm.obj	a fitted Tweedie glm object
dispersion	the dispersion parameter $\phi$ ; the default is NULL which means to use an estimate
k	numeric: the penalty per parameter to be used; the default is $k = 2$
verbose	if TRUE (the default), a warning message is produced about the Poisson case; see the second Note below

### Details

See [AIC](#) for more details on the AIC; see [dtweedie](#) for more details on computing the Tweedie densities

### Value

Returns a numeric value with the corresponding AIC (or BIC, depending on  $k$ )

### Note

Computing the AIC may take a long time.

**Note**

Tweedie distributions with the index parameter as 1 correspond to Poisson distributions when  $\phi = 1$ . However, in general a Tweedie distribution with an index parameter equal to one may not be referring to a Poisson distribution with  $\phi = 1$ , so we cannot assume that  $\phi = 1$  just because the index parameter is set to one. If the Poisson distribution is intended, then dispersion=1 should be specified. The same argument applies for similar situations.

**Author(s)**

Peter Dunn (<pdunn2@usc.edu.au>)

**References**

Dunn, P. K. and Smyth, G. K. (2008). Evaluation of Tweedie exponential dispersion model densities by Fourier inversion. *Statistics and Computing*, **18**, 73–86. doi: [10.1007/s1122200790396](https://doi.org/10.1007/s1122200790396)

Dunn, Peter K and Smyth, Gordon K (2005). Series evaluation of Tweedie exponential dispersion model densities *Statistics and Computing*, **15**(4). 267–280. doi: [10.1007/s112220054070y](https://doi.org/10.1007/s112220054070y)

Jorgensen, B. (1997). *Theory of Dispersion Models*. Chapman and Hall, London.

Sakamoto, Y., Ishiguro, M., and Kitagawa G. (1986). *Akaike Information Criterion Statistics*. D. Reidel Publishing Company.

**See Also**

[AIC](#)

**Examples**

```
library(statmod) # Needed to use tweedie family object

### Generate some fictitious data
test.data <- rgamma(n = 200, scale = 1, shape = 1)

### Fit a Tweedie glm and find the AIC
m1 <- glm( test.data ~ 1, family = tweedie(link.power = 0, var.power = 2) )

### A Tweedie glm with p=2 is equivalent to a gamma glm:
m2 <- glm( test.data ~ 1, family = Gamma(link = log))

### The models are equivalent, so the AIC should be the same:
AICtweedie(m1)
AIC(m2)
```

---

dtweedie.dldphi      *Tweedie Distributions*


---

### Description

Derivatives of the log-likelihood with respect to  $\phi$

### Usage

```
dtweedie.dldphi(phi, mu, power, y )
dtweedie.dldphi.saddle(phi, mu, power, y )
```

### Arguments

y	vector of quantiles
mu	the mean
phi	the dispersion
power	the value of $p$ such that the variance is $\text{var}[Y] = \phi\mu^p$

### Details

The Tweedie family of distributions belong to the class of exponential dispersion models (EDMs), famous for their role in generalized linear models. The Tweedie distributions are the EDMs with a variance of the form  $\text{var}[Y] = \phi\mu^p$  where  $p$  is greater than or equal to one, or less than or equal to zero. **This function only evaluates for  $p$  greater than or equal to one.** Special cases include the normal ( $p = 0$ ), Poisson ( $p = 1$  with  $\phi = 1$ ), gamma ( $p = 2$ ) and inverse Gaussian ( $p = 3$ ) distributions. For other values of power, the distributions are still defined but cannot be written in closed form, and hence evaluation is very difficult.

### Value

the value of the derivative  $\partial\ell/\partial\phi$  where  $\ell$  is the log-likelihood for the specified Tweedie distribution. `dtweedie.dldphi.saddle` uses the saddlepoint approximation to determine the derivative; `dtweedie.dldphi` uses an infinite series expansion.

### Author(s)

Peter Dunn (<pdunn2@usc.edu.au>)

### References

Dunn, P. K. and Smyth, G. K. (2008). Evaluation of Tweedie exponential dispersion model densities by Fourier inversion. *Statistics and Computing*, **18**, 73–86. doi: [10.1007/s1122200790396](https://doi.org/10.1007/s1122200790396)

Dunn, Peter K and Smyth, Gordon K (2005). Series evaluation of Tweedie exponential dispersion model densities *Statistics and Computing*, **15**(4). 267–280. doi: [10.1007/s112220054070y](https://doi.org/10.1007/s112220054070y)

Dunn, Peter K and Smyth, Gordon K (2001). Tweedie family densities: methods of evaluation. *Proceedings of the 16th International Workshop on Statistical Modelling*, Odense, Denmark, 2–6 July

Jorgensen, B. (1987). Exponential dispersion models. *Journal of the Royal Statistical Society, B*, **49**, 127–162.

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Sidi, Avram (1982). The numerical evaluation of very oscillatory infinite integrals by extrapolation. *Mathematics of Computation* **38**(158), 517–529. doi: [10.1090/S00255718198206456675](https://doi.org/10.1090/S00255718198206456675)

Sidi, Avram (1988). A user-friendly extrapolation method for oscillatory infinite integrals. *Mathematics of Computation* **51**(183), 249–266. doi: [10.1090/S00255718198809421535](https://doi.org/10.1090/S00255718198809421535)

Tweedie, M. C. K. (1984). An index which distinguishes between some important exponential families. *Statistics: Applications and New Directions. Proceedings of the Indian Statistical Institute Golden Jubilee International Conference* (Eds. J. K. Ghosh and J. Roy), pp. 579-604. Calcutta: Indian Statistical Institute.

## See Also

[dtweedie.saddle](#), [dtweedie](#), [tweedie.profile](#), [tweedie](#)

## Examples

```
### Plot dl/dphi against candidate values of phi
power <- 2
mu <- 1
phi <- seq(2, 8, by = 0.1)

set.seed(10000) # For reproducibility
y <- rtweedie( 100, mu = mu, power = power, phi = 3)
# So we expect the maximum to occur at phi = 3

dldphi <- dldphi.saddle <- array( dim = length(phi))

for (i in (1:length(phi))) {
  dldphi[i] <- dtweedie.dldphi(y = y, power = power, mu = mu, phi = phi[i])
  dldphi.saddle[i] <- dtweedie.dldphi.saddle(y = y, power = power, mu = mu, phi = phi[i])
}

plot( dldphi ~ phi, lwd = 2, type = "l",
      ylab = expression(phi), xlab = expression(paste("dl / d",phi) ) )
lines( dldphi.saddle ~ phi, lwd = 2, col = 2, lty = 2)
legend( "bottomright", lwd = c(2, 2), lty = c(1, 2), col = c(1, 2),
       legend = c("'Exact' (using series)", "Saddlepoint") )

# Neither are very good in this case!
```

---

 dtweedie.saddle      *Tweedie Distributions (saddlepoint approximation)*


---

**Description**

Saddlepoint density for the Tweedie distributions

**Usage**

```
dtweedie.saddle(y, xi=NULL, mu, phi, eps=1/6, power=NULL)
```

**Arguments**

y	the vector of responses
xi	the value of $\xi$ such that the variance is $\text{var}[Y] = \phi\mu^\xi$
power	a synonym for $\xi$
mu	the mean
phi	the dispersion
eps	the offset in computing the variance function. The default is $\text{eps}=1/6$ (as suggested by Nelder and Pregibon, 1987).

**Details**

The Tweedie family of distributions belong to the class of exponential dispersion models (EDMs), famous for their role in generalized linear models. The Tweedie distributions are the EDMs with a variance of the form  $\text{var}[Y] = \phi\mu^p$  where  $p$  is greater than or equal to one, or less than or equal to zero. **This function only evaluates for  $p$  greater than or equal to one.** Special cases include the normal ( $p = 0$ ), Poisson ( $p = 1$  with  $\phi = 1$ ), gamma ( $p = 2$ ) and inverse Gaussian ( $p = 3$ ) distributions. For other values of power, the distributions are still defined but cannot be written in closed form, and hence evaluation is very difficult.

When  $1 < p < 2$ , the distribution are continuous for  $Y$  greater than zero, with a positive mass at  $Y = 0$ . For  $p > 2$ , the distributions are continuous for  $Y$  greater than zero.

This function approximates the density using the saddlepoint approximation defined by Nelder and Pregibon (1987).

**Value**

saddlepoint (approximate) density for the given Tweedie distribution with parameters mu, phi and power.

**Author(s)**

Peter Dunn (<pdunn2@usc.edu.au>)

## References

- Daniels, H. E. (1954). Saddlepoint approximations in statistics. *Annals of Mathematical Statistics*, **25**(4), 631–650.
- Daniels, H. E. (1980). Exact saddlepoint approximations. *Biometrika*, **67**, 59–63. doi: [10.1093/biomet/67.1.59](https://doi.org/10.1093/biomet/67.1.59)
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- Tweedie, M. C. K. (1984). An index which distinguishes between some important exponential families. *Statistics: Applications and New Directions. Proceedings of the Indian Statistical Institute Golden Jubilee International Conference* (Eds. J. K. Ghosh and J. Roy), pp. 579-604. Calcutta: Indian Statistical Institute.

## See Also

[dtweedie](#)

## Examples

```
p <- 2.5
mu <- 1
phi <- 1
y <- seq(0, 10, length = 100)
fy <- dtweedie( y = y, power = p, mu = mu, phi = phi)
plot(y, fy, type = "l")
# Compare to the saddlepoint density
f.saddle <- dtweedie.saddle(y = y, power = p, mu = mu, phi = phi)
lines( y, f.saddle, col = 2 )
```

---

logLikTweedie

*Tweedie Distributions*

---

## Description

The log likelihood for Tweedie models

**Usage**

```
logLikTweedie( glm.obj, dispersion=NULL)
```

**Arguments**

glm.obj	a fitted Tweedie glm object
dispersion	the dispersion parameter $\phi$ ; the default is NULL which means to use an estimate

**Details**

The log-likelihood is computed from the AIC, so see [AICtweedie](#) for more details.

**Value**

Returns the log-likelihood from the specified model

**Note**

Computing the log-likelihood may take a long time.

**Note**

Tweedie distributions with the index parameter as 1 correspond to Poisson distributions when  $\phi = 1$ . However, in general a Tweedie distribution with an index parameter equal to one may not be referring to a Poisson distribution with  $\phi = 1$ , so we cannot assume that  $\phi = 1$  just because the index parameter is set to one. If the Poisson distribution is intended, then `dispersion=1` should be specified. The same argument applies for similar situations.

**Author(s)**

Peter Dunn (<pdunn2@usc.edu.au>)

**References**

- Dunn, P. K. and Smyth, G. K. (2008). Evaluation of Tweedie exponential dispersion model densities by Fourier inversion. *Statistics and Computing*, **18**, 73–86. doi: [10.1007/s1122200790396](https://doi.org/10.1007/s1122200790396)
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- Jorgensen, B. (1997). *Theory of Dispersion Models*. Chapman and Hall, London.
- Sakamoto, Y., Ishiguro, M., and Kitagawa G. (1986). *Akaike Information Criterion Statistics*. D. Reidel Publishing Company.

**See Also**

[AICtweedie](#)

**Examples**

```

library(statmod) # Needed to use tweedie family object

### Generate some fictitious data
test.data <- rgamma(n = 200, scale = 1, shape = 1)

### Fit a Tweedie glm and find the AIC
m1 <- glm( test.data ~ 1, family = tweedie(link.power = 0, var.power = 2) )

### A Tweedie glm with p=2 is equivalent to a gamma glm:
m2 <- glm( test.data ~ 1, family = Gamma(link = log))

### The models are equivalent, so the AIC should be the same:
logLikTweedie(m1)
logLik(m2)

```

---

Tweedie

*Tweedie Distributions*


---

**Description**

Density, distribution function, quantile function and random generation for the Tweedie family of distributions

**Usage**

```

dtweedie(y, xi=NULL, mu, phi, power=NULL)
dtweedie.series(y, power, mu, phi)
dtweedie.inversion(y, power, mu, phi, exact=TRUE, method)
dtweedie.stable(y, power, mu, phi)
ptweedie(q, xi=NULL, mu, phi, power=NULL)
ptweedie.series(q, power, mu, phi)
qtweedie(p, xi=NULL, mu, phi, power=NULL)
rtweedie(n, xi=NULL, mu, phi, power=NULL)

```

**Arguments**

y, q	vector of quantiles
p	vector of probabilities
n	the number of observations
xi	the value of $\xi$ such that the variance is $\text{var}[Y] = \phi\mu^\xi$
power	a synonym for $\xi$
mu	the mean
phi	the dispersion

exact	logical flag; if TRUE (the default), exact zeros are used with the $W$ -algorithm of Sidi (1982); if FALSE, approximate (asymptotic) zeros are used in place of exact zeros. Using asymptotic zeros requires less computation but is often less accurate; using exact zeros can be slower but generally improves accuracy.
method	either 1, 2 or 3, determining which of three methods to use to compute the density using the inversion method. If method is NULL (the default), the optimal method (in terms of relative accuracy) is used, element-by-element of $y$ . See the Note in the Details section below

### Details

The Tweedie family of distributions belong to the class of exponential dispersion models (EDMs), famous for their role in generalized linear models. The Tweedie distributions are the EDMs with a variance of the form  $\text{var}[Y] = \phi\mu^p$  where  $p$  is greater than or equal to one, or less than or equal to zero. **This function only evaluates for  $p$  greater than or equal to one.** Special cases include the normal ( $p = 0$ ), Poisson ( $p = 1$  with  $\phi = 1$ ), gamma ( $p = 2$ ) and inverse Gaussian ( $p = 3$ ) distributions. For other values of power, the distributions are still defined but cannot be written in closed form, and hence evaluation is very difficult.

When  $1 < p < 2$ , the distribution are continuous for  $Y$  greater than zero, with a positive mass at  $Y = 0$ . For  $p > 2$ , the distributions are continuous for  $Y$  greater than zero.

This function evaluates the density or cumulative probability using one of two methods, depending on the combination of parameters. One method is the evaluation of an infinite series. The second interpolates some stored values computed from a Fourier inversion technique.

The function `dtweedie.inversion` evaluates the density using a Fourier series technique; `ptweedie.inversion` does likewise for the cumulative probabilities. The actual code is contained in an external FORTRAN program. Different code is used for  $p > 2$  and for  $1 < p < 2$ .

The function `dtweedie.series` evaluates the density using a series expansion; a different series expansion is used for  $p > 2$  and for  $1 < p < 2$ . The function `ptweedie.series` does likewise for the cumulative probabilities but only for  $1 < p < 2$ .

The function `dtweedie.stable` exploits the link between the stable distribution (Nolan, 1997) and Tweedie distributions, as discussed in Jorgensen, Chapter 4. These are computed using Nolan's algorithm as implemented in the `stabledist` package (which is therefore required to use the `dtweedie.stable` function).

The function `dtweedie` uses a two-dimensional interpolation procedure to compute the density for some parts of the parameter space from previously computed values found from the series or the inversion. For other parts of the parameter space, the series solution is found.

`ptweedie` returns either the computed series solution or inversion solution.

### Value

density (`dtweedie`), probability (`ptweedie`), quantile (`qtweedie`) or random sample (`rtweedie`) for the given Tweedie distribution with parameters `mu`, `phi` and `power`.

### Note

The methods changed from version 1.4 to 1.5 (methods 1 and 2 swapped). The methods are defined in Dunn and Smyth (2008).

**Author(s)**

Peter Dunn (<pdunn2@usc.edu.au>)

**References**

- Dunn, P. K. and Smyth, G. K. (2008). Evaluation of Tweedie exponential dispersion model densities by Fourier inversion. *Statistics and Computing*, **18**, 73–86. doi: [10.1007/s1122200790396](https://doi.org/10.1007/s1122200790396)
- Dunn, Peter K and Smyth, Gordon K (2005). Series evaluation of Tweedie exponential dispersion model densities *Statistics and Computing*, **15**(4). 267–280. doi: [10.1007/s112220054070y](https://doi.org/10.1007/s112220054070y)
- Dunn, Peter K and Smyth, Gordon K (2001). Tweedie family densities: methods of evaluation. *Proceedings of the 16th International Workshop on Statistical Modelling*, Odense, Denmark, 2–6 July
- Jorgensen, B. (1987). Exponential dispersion models. *Journal of the Royal Statistical Society, B*, **49**, 127–162.
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- Sidi, Avram (1982). The numerical evaluation of very oscillatory infinite integrals by extrapolation. *Mathematics of Computation* **38**(158), 517–529. doi: [10.1090/S00255718198206456675](https://doi.org/10.1090/S00255718198206456675)
- Sidi, Avram (1988). A user-friendly extrapolation method for oscillatory infinite integrals. *Mathematics of Computation* **51**(183), 249–266. doi: [10.1090/S00255718198809421535](https://doi.org/10.1090/S00255718198809421535)
- Tweedie, M. C. K. (1984). An index which distinguishes between some important exponential families. *Statistics: Applications and New Directions. Proceedings of the Indian Statistical Institute Golden Jubilee International Conference* (Eds. J. K. Ghosh and J. Roy), pp. 579-604. Calcutta: Indian Statistical Institute.

**See Also**

[dtweedie.saddle](#)

**Examples**

```
### Plot a Tweedie density
power <- 2.5
mu <- 1
phi <- 1
y <- seq(0, 6, length = 500)
fy <- dtweedie(y = y, power = power, mu = mu, phi = phi)
plot(y, fy, type = "l", lwd = 2, ylab = "Density")
# Compare to the saddlepoint density
f.saddle <- dtweedie.saddle( y = y, power = power, mu = mu, phi = phi)
lines( y, f.saddle, col = 2 )
legend("topright", col = c(1, 2), lwd = c(2, 1),
      legend = c("Actual", "Saddlepoint") )

### A histogram of Tweedie random numbers
hist( rtweedie( 1000, power = 1.2, mu = 1, phi = 1 ) )
```

```

### An example of the multimodal feature of the Tweedie
### family with power near 1 (from Dunn and Smyth, 2005).
y <- seq(0.001, 2, len = 1000)
mu <- 1
phi <- 0.1
p <- 1.02
f1 <- dtweedie(y, mu = mu, phi = phi, power = p)
plot(y, f1, type = "l", xlab = "y", ylab = "Density")
p <- 1.05
f2 <- dtweedie(y, mu = mu, phi = phi, power = p)
lines(y, f2, col = 2)

### Compare series and saddlepoint methods
y <- seq(0.001, 2, len=1000)
mu <- 1
phi <- 0.1
p <- 1.02
f.series <- dtweedie.series(y, mu = mu, phi = phi, power = p )
f.saddle <- dtweedie.saddle(y, mu = mu, phi = phi, power = p )

f.all <- c( f.series, f.saddle )
plot( range(f.all) ~ range( y ), xlab = "y", ylab = "Density",
      type = "n")
lines( f.series ~ y, lty = 1, col = 1)
lines( f.saddle ~ y, lty = 3, col = 3)

legend("topright", lty = c(1, 3), col = c(1, 3),
      legend = c("Series", "Saddlepoint") )

```

---

Tweedie internals

*Tweedie internal function*


---

## Description

Internal tweedie functions.

## Usage

```

dtweedie.dlogfdphi(y, mu, phi, power)
dtweedie.logl(phi, y, mu, power)
dtweedie.logl.saddle( phi, power, y, mu, eps=0)
dtweedie.logv.bigp( y, phi, power)
dtweedie.logw.smallp(y, phi, power)
dtweedie.interp(grid, nx, np, xix.lo, xix.hi, p.lo, p.hi, power, xix)
dtweedie.jw.smallp(y, phi, power )
dtweedie.kv.bigp(y, phi, power)
dtweedie.series.bigp(power, y, mu, phi)

```

```
dtweedie.series.smallp(power, y, mu, phi)
stored.grids(power)
twpdf(p, phi, y, mu, exact, verbose, funvalue, exitstatus, relerr, its )
twcdf(p, phi, y, mu, exact,          funvalue, exitstatus, relerr, its )
```

### Arguments

y	the vector of responses
power	the value of $p$ such that the variance is $\text{var}[Y] = \phi\mu^p$
mu	the mean
phi	the dispersion
grid	the interpolation grid necessary for the given value of $p$
nx	the number of interpolation points in the $\xi$ dimension
np	the number of interpolation points in the $p$ dimension
xix.lo	the lower value of the transformed $\xi$ value used in the interpolation grid. (Note that the value of $\xi$ is from 0 to $\infty$ , and is transformed such that it is on the range 0 to 1.)
xix.hi	the higher value of the transformed $\xi$ value used in the interpolation grid.
p.lo	the lower value of $p$ value used in the interpolation grid.
p.hi	the higher value of $p$ value used in the interpolation grid.
xix	the value of the transformed $\xi$ at which a value is sought.
eps	the offset in computing the variance function in the saddlepoint approximation. The default is $\text{eps}=1/6$ (as suggested by Nelder and Pregibon, 1987).
p	the Tweedie index parameter
exact	a flag for the FORTRAN to use exact-zeros acceleration algorithmic the calculation (1 means to do so)
verbose	a flag for the FORTRAN: 1 means to be verbose
funvalue	the value of the call returned by the FORTRAN code
exitstatus	the exit status returned by the FORTRAN code
relerr	an estimation of the relative error returned by the FORTRAN code
its	the number of iterations of the algorithm returned by the FORTRAN code

### Details

These are not to be called by the user.

### Author(s)

Peter Dunn (<pdunn2@usc.edu.au>)

### References

Nelder, J. A. and Pregibon, D. (1987). An extended quasi-likelihood function *Biometrika*, **74**(2), 221–232. doi10.1093/biomet/74.2.221

---

tweedie.convert	<i>Convert Tweedie parameters</i>
-----------------	-----------------------------------

---

## Description

Converts Tweedie distribution parameters to the parameters of the underlying distributions

## Usage

```
tweedie.convert( xi=NULL, mu, phi, power=NULL)
```

## Arguments

xi	the value of $\xi$ such that the variance is $\text{var}[Y] = \phi\mu^\xi$
power	a synonym for $\xi$
mu	the mean
phi	the dispersion

## Details

The Tweedie family of distributions with  $1 < \xi < 2$  is the Poisson sum of gamma distributions (where the Poisson distribution has mean  $\lambda$ , and the gamma distribution has scale and shape parameters). When used to fit a glm, the model is fitted with the usual glm parameters: the mean  $\mu$  and the dispersion parameter  $\phi$ . This function converts the parameters  $(p, \mu, \phi)$  to the values of the parameters of the underlying Poisson distribution  $\lambda$  and gamma distribution (scale and shape parameters).

## Value

a list containing the values of the mean of the underlying Poisson distribution (as `poisson.lambda`), the scale parameter of the underlying gamma distribution (as `gamma.scale`), the shape parameter of the underlying gamma distribution (as `gamma.shape`), the probability of obtaining a zero response (as `p0`), the mean of the underlying gamma distribution (as `gamma.mean`), and the dispersion parameter of the underlying gamma distribution (as `gamma.phi`).

## Author(s)

Peter Dunn (<[pdunn2@usc.edu.au](mailto:pdunn2@usc.edu.au)>)

## References

- Dunn, P. K. and Smyth, G. K. (2008). Evaluation of Tweedie exponential dispersion model densities by Fourier inversion. *Statistics and Computing*, **18**, 73–86. doi: [10.1007/s1122200790396](https://doi.org/10.1007/s1122200790396)
- Dunn, Peter K and Smyth, Gordon K (2005). Series evaluation of Tweedie exponential dispersion model densities *Statistics and Computing*, **15**(4). 267–280. doi: [10.1007/s112220054070y](https://doi.org/10.1007/s112220054070y)

Dunn, Peter K and Smyth, Gordon K (2001). Tweedie family densities: methods of evaluation. *Proceedings of the 16th International Workshop on Statistical Modelling*, Odense, Denmark, 2–6 July

Tweedie, M. C. K. (1984). An index which distinguishes between some important exponential families. *Statistics: Applications and New Directions. Proceedings of the Indian Statistical Institute Golden Jubilee International Conference* (Eds. J. K. Ghosh and J. Roy), pp. 579-604. Calcutta: Indian Statistical Institute.

### See Also

[dtweedie.saddle](#)

### Examples

```
tweedie.convert(xi = 1.5, mu = 1, phi = 1)
```

---

tweedie.dev

*Tweedie Distributions: the deviance function*

---

### Description

The deviance function for the Tweedie family of distributions

### Usage

```
tweedie.dev(y, mu, power)
```

### Arguments

y	vector of quantiles (which can be zero if $1 < p < 2$ )
mu	the mean
power	the value of $p$ such that the variance is $\text{var}[Y] = \phi\mu^p$

### Details

The Tweedie family of distributions belong to the class of exponential dispersion models (EDMs), famous for their role in generalized linear models. The Tweedie distributions are the EDMs with a variance of the form  $\text{var}[Y] = \phi\mu^p$  where  $p$  is greater than or equal to one, or less than or equal to zero. **This function only evaluates for  $p$  greater than or equal to one.** Special cases include the normal ( $p = 0$ ), Poisson ( $p = 1$  with  $\phi = 1$ ), gamma ( $p = 2$ ) and inverse Gaussian ( $p = 3$ ) distributions. For other values of power, the distributions are still defined but cannot be written in closed form, and hence evaluation is very difficult.

The deviance is defined by [deviance](#) as “up to a constant, minus twice the maximized log-likelihood. Where sensible, the constant is chosen so that a saturated model has deviance zero.”

### Value

the value of the deviance for the given Tweedie distribution with parameters mu, phi and power.

**Author(s)**

Peter Dunn (<pdunn2@usc.edu.au>)

**References**

- Dunn, P. K. and Smyth, G. K. (2008). Evaluation of Tweedie exponential dispersion model densities by Fourier inversion. *Statistics and Computing*, **18**, 73–86. doi: [10.1007/s1122200790396](https://doi.org/10.1007/s1122200790396)
- Dunn, Peter K and Smyth, Gordon K (2005). Series evaluation of Tweedie exponential dispersion model densities *Statistics and Computing*, **15**(4), 267–280. doi: [10.1007/s112220054070y](https://doi.org/10.1007/s112220054070y)
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- Jorgensen, B. (1997). *Theory of Dispersion Models*. Chapman and Hall, London.
- Sidi, Avram (1982). The numerical evaluation of very oscillatory infinite integrals by extrapolation. *Mathematics of Computation* **38**(158), 517–529. doi: [10.1090/S00255718198206456675](https://doi.org/10.1090/S00255718198206456675)
- Sidi, Avram (1988). A user-friendly extrapolation method for oscillatory infinite integrals. *Mathematics of Computation* **51**(183), 249–266. doi: [10.1090/S00255718198809421535](https://doi.org/10.1090/S00255718198809421535)
- Tweedie, M. C. K. (1984). An index which distinguishes between some important exponential families. *Statistics: Applications and New Directions. Proceedings of the Indian Statistical Institute Golden Jubilee International Conference* (Eds. J. K. Ghosh and J. Roy), pp. 579-604. Calcutta: Indian Statistical Institute.

**See Also**

[dtweedie](#), [dtweedie.saddle](#), [tweedie](#), [deviance](#), [glm](#)

**Examples**

```
### Plot a Tweedie deviance function when 1<p<2
mu <- 1

y <- seq(0, 6, length = 100)

dev1 <- tweedie.dev(y = y, mu = mu, power = 1.1)
dev2 <- tweedie.dev(y = y, mu = mu, power = 1.5)
dev3 <- tweedie.dev(y = y, mu = mu, power = 1.9)

plot(range(y), range( c(dev1, dev2, dev3)),
      type = "n", lwd = 2, ylab = "Deviance", xlab = expression(italic(y)) )

lines(y, dev1, lty = 1, col = 1, lwd = 2)
lines(y, dev2, lty = 2, col = 2, lwd = 2)
lines(y, dev3, lty = 3, col = 3, lwd = 2)

legend("top", col = c(1, 2, 3), lwd = c(2, 2, 2), lty = c(1, 2, 3),
```

```

legend = c("p=1.1", "p=1.5", "p=1.9") )

### Plot a Tweedie deviance function when p>2
mu <- 1

y <- seq(0.1, 6, length = 100)

dev1 <- tweedie.dev(y = y, mu=mu, power=2) # Gamma
dev2 <- tweedie.dev(y = y, mu=mu, power=3) # Inverse Gaussian
dev3 <- tweedie.dev(y = y, mu=mu, power=4)

plot(range(y), range( c(dev1, dev2, dev3)),
      type="n", lwd=2, ylab="Deviance", xlab=expression(italic(y)) )

lines( y, dev1, lty = 1, col = 1, lwd = 2 )
lines( y, dev2, lty = 2, col = 2, lwd = 2 )
lines( y, dev3, lty = 3, col = 3, lwd = 2 )

legend("top", col = c(1, 2, 3), lwd = c(2, 2, 2), lty = c(1, 2, 3),
      legend = c("p=2 (gamma)", "p=3 (inverse Gaussian)", "p=4") )

```

---

tweedie.plot

*Tweedie Distributions: plotting*


---

## Description

Plotting Tweedie density and distribution functions

## Usage

```
tweedie.plot(y, xi, mu, phi, type="pdf", power=NULL, add=FALSE, ...)
```

## Arguments

y	vector of values at which to evaluate and plot
xi	the value of $\xi$ such that the variance is $\text{var}[Y] = \phi\mu^\xi$
power	a synonym for $\xi$
mu	the mean
phi	the dispersion
type	what to plot: pdf (the default) means the probability function, or cdf, the cumulative distribution function
add	if TRUE, the plot is added to the current device; if FALSE (the default), a new plot is produced
...	Arguments to be passed to the plotting method

## Details

For details, see [dtweedie](#)

## Value

this function is usually called for side-effect of producing a plot of the specified Tweedie distribution, properly plotting the exact zero that occurs at  $y = 0$  when  $1 < p < 2$ . However, it also produces a list with the computed density at the given points, with components `y` and `x` respectively, such that `plot(y~x)` approximately reproduces the plot.

## Author(s)

Peter Dunn (<pdunn2@usc.edu.au>)

## References

- Dunn, P. K. and Smyth, G. K. (2008). Evaluation of Tweedie exponential dispersion model densities by Fourier inversion. *Statistics and Computing*, **18**, 73–86. doi: [10.1007/s1122200790396](https://doi.org/10.1007/s1122200790396)
- Dunn, Peter K and Smyth, Gordon K (2005). Series evaluation of Tweedie exponential dispersion model densities *Statistics and Computing*, **15**(4). 267–280. doi: [10.1007/s112220054070y](https://doi.org/10.1007/s112220054070y)
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- Sidi, Avram (1982). The numerical evaluation of very oscillatory infinite integrals by extrapolation. *Mathematics of Computation* **38**(158), 517–529. doi: [10.1090/S00255718198206456675](https://doi.org/10.1090/S00255718198206456675)
- Sidi, Avram (1988). A user-friendly extrapolation method for oscillatory infinite integrals. *Mathematics of Computation* **51**(183), 249–266. doi: [10.1090/S00255718198809421535](https://doi.org/10.1090/S00255718198809421535)
- Tweedie, M. C. K. (1984). An index which distinguishes between some important exponential families. *Statistics: Applications and New Directions. Proceedings of the Indian Statistical Institute Golden Jubilee International Conference* (Eds. J. K. Ghosh and J. Roy), pp. 579-604. Calcutta: Indian Statistical Institute.

## See Also

[dtweedie](#)

## Examples

```
### Plot a Tweedie density with 1<p<2
yy <- seq(0, 5, length = 100)
tweedie.plot( power = 1.7, mu = 1, phi = 1, y = yy, lwd = 2)
tweedie.plot( power = 1.2, mu = 1, phi = 1, y = yy, add = TRUE, lwd = 2, col = "red")
```

```

legend("topright", lwd = c(2, 2), col = c("black", "red"), pch = c(19, 19),
      legend = c("p=1.7", "p=1.2") )

### Plot distribution functions
tweedie.plot( power = 1.05, mu = 1, phi = 1, y = yy,
             lwd = 2, type = "cdf", ylim = c(0, 1))
tweedie.plot( power = 2, mu = 1, phi = 1, y = yy,
             add = TRUE, lwd = 2, type = "cdf", col = "red")
legend("bottomright", lwd = c(2, 2), col = c("black", "red"),
      legend = c("p=1.05", "p=2") )

### Now, plot two densities, combining p>2 and 1<p<2
tweedie.plot( power = 3.5, mu = 1, phi = 1, y = yy, lwd = 2)
tweedie.plot( power = 1.5, mu = 1, phi = 1, y = yy, lwd = 2, col = "red", add = TRUE)
legend("topright", lwd = c(2, 2), col = c("black", "red"), pch = c(NA, 19),
      legend = c("p=3.5", "p=1.5") )

```

---

tweedie.profile

*Tweedie Distributions: mle estimation of p*


---

## Description

Maximum likelihood estimation of the Tweedie index parameter  $p$ .

## Usage

```

tweedie.profile(formula, p.vec=NULL, xi.vec=NULL, link.power=0,
               data, weights, offset, fit.glm=FALSE,
               do.smooth=TRUE, do.plot=FALSE, do.ci=do.smooth,
               eps=1/6,
               control=list( epsilon=1e-09, maxit=glm.control()$maxit, trace=glm.control()$trace ),
               do.points=do.plot, method="inversion", conf.level=0.95,
               phi.method=ifelse(method == "saddlepoint", "saddlepoint", "mle"),
               verbose=FALSE, add0=FALSE)

```

## Arguments

formula	a formula expression as for other regression models and generalized linear models, of the form response ~ predictors. For details, see the documentation for <a href="#">lm</a> , <a href="#">glm</a> and <a href="#">formula</a>
p.vec	a vector of $p$ values for consideration. The values must all be larger than one (if the response variable has exact zeros, the values must all be between one and two). If NULL (the default), p.vec is set to seq(1.2, 1.8, by=0.1) if the response contains any zeros, or seq(1.5, 5, by=0.5) if the response contains no zeros. See the DETAILS section below for further details.
xi.vec	the same as p.vec; some authors use the $p$ notation for the index parameter, and some use $\xi$ ; this function detects which is used and then uses that notation throughout

link.power	the power link function to use. These link functions $g(\cdot)$ are of the form $g(\eta) = \eta^{\text{link.power}}$ , and the special case of link.power=0 (the default) refers to the logarithm link function. See the documentation for <a href="#">tweedie</a> also.
data	an optional data frame, list or environment (or object coercible by <code>as.data.frame</code> to a data frame) containing the variables in the model. If not found in data, the variables are taken from <code>environment(formula)</code> , typically the environment from which <code>glm</code> is called.
weights	an optional vector of weights to be used in the fitting process. Should be NULL or a numeric vector.
offset	this can be used to specify an <i>a priori</i> known component to be included in the linear predictor during fitting. This should be NULL or a numeric vector of length either one or equal to the number of cases. One or more offset terms can be included in the formula instead or as well, and if both are specified their sum is used. See <a href="#">model.offset</a> .
fit.glm	logical flag. If TRUE, the Tweedie generalized linear model is fitted using the value of $p$ found by the profiling function. If FALSE (the default), no model is fitted.
do.smooth	logical flag. If TRUE (the default), a spline is fitted to the data to smooth the profile likelihood plot. If FALSE, no smoothing is used (and the function is quicker). <b>Note</b> that <code>p.vec</code> must contain <i>at least five points</i> for smoothing to be allowed.
do.plot	logical flag. If TRUE, a plot of the profile likelihood is produce. If FALSE (the default), no plot is produced.
do.ci	logical flag. If TRUE, the nominal $100 \times \text{conf.level}$ is computed. If FALSE, no confidence interval is computed. By default, <code>do.ci</code> is the same value as <code>do.smooth</code> , since a confidence interval will only be accurate if smoothing has been performed. Indeed, if <code>do.smooth=FALSE</code> , confidence intervals are never computed and <code>do.ci</code> is forced to FALSE if it is given as TRUE.
eps	the offset in computing the variance function. The default is <code>eps=1/6</code> (as suggested by Nelder and Pregibon, 1987). Note <code>eps</code> is ignored unless the <code>method="saddlepoint"</code> as it makes no sense otherwise.
control	a list of parameters for controlling the fitting process; see <a href="#">glm.control</a> and <a href="#">glm</a> . The default is to use the maximum number of iterations <code>maxit</code> and the trace setting as given in <a href="#">glm.control</a> , but to set <code>epsilon</code> to $1e-09$ to ensure a smoother plot
do.points	plot the points on the plot where the (log-) likelihood is computed for the given values of $p$ ; defaults to the same value as <code>do.plot</code>
method	the method for computing the (log-) likelihood. One of "series", "inversion" (the default), "interpolation" or "saddlepoint". If there are any troubles using this function, often a change of method will fix the problem. Note that <code>method="saddlepoint"</code> is only an approximate method for computing the (log-) likelihood. Using <code>method="interpolation"</code> may produce a jump in the profile likelihood as it changes computational regimes.
conf.level	the confidence level for the computation of the nominal confidence interval. The default is <code>conf.level=0.95</code> .

<code>phi.method</code>	the method for estimating $\phi$ , one of "saddlepoint" or "mle". A maximum likelihood estimate is used unless <code>method="saddlepoint"</code> , when the saddlepoint approximation method is used. Note that using <code>phi.method="saddlepoint"</code> is equivalent to using the mean deviance estimator of $\phi$ .
<code>verbose</code>	the amount of feedback requested: 0 or FALSE means minimal feedback (the default), 1 or TRUE means some feedback, or 2 means to show all feedback. Since the function can be slow and sometimes problematic, feedback can be good; but it can also be unnecessary when one knows all is well.
<code>add0</code>	if TRUE, the value $p=0$ is used in forming the profile log-likelihood (corresponding to the normal distribution); the default value is <code>add0=FALSE</code>

### Details

For each value in `p.vec`, the function computes an estimate of  $\phi$  and then computes the value of the log-likelihood for these parameters. The plot of the log-likelihood against `p.vec` allows the maximum likelihood value of  $p$  to be found. Once the value of  $p$  is found, the distribution within the class of Tweedie distribution is identified.

### Value

The main purpose of the function is to estimate the value of the Tweedie index parameter,  $p$ , which is produced by the output list as `p.max`. Optionally (if `do.plot=TRUE`), a plot is produced that shows the profile log-likelihood computed at each value in `p.vec` (smoothed if `do.smooth=TRUE`). This function can be temperamental (for theoretical reasons involved in numerically computing the density), and this plot shows the values of  $p$  requested on the horizontal axis (using `rug`); there may be fewer points on the plot, since the likelihood some values of  $p$  requested may have returned NaN, Inf or NA.

A list containing the components: `y` and `x` (such that `plot(x,y)` (partially) recreates the profile likelihood plot); `ht` (the height of the nominal confidence interval); `L` (the estimate of the (log-) likelihood at each given value of  $p$ ); `p` (the  $p$ -values used); `phi` (the computed values of  $\phi$  at the values in `p`); `p.max` (the estimate of the mle of  $p$ ); `L.max` (the estimate of the (log-) likelihood at `p.max`); `phi.max` (the estimate of  $\phi$  at `p.max`); `ci` (the lower and upper limits of the confidence interval for  $p$ ); `method` (the method used for estimation: `series`, `inversion`, `interpolation` or `saddlepoint`); `phi.method` (the method used for estimation of  $\phi$ : `saddlepoint` or `phi`).

If `glm.fit` is TRUE, the list also contains a component `glm.obj`, a `glm` object for the fitted Tweedie generalized linear model.

### Note

The estimates of  $p$  and  $\phi$  are printed. The result is printed invisibly.

If the response variable has any exact zeros, the values in `p.vec` must all be between one and two.

The function is sometimes unstable and may fail. It may also be very slow. One solution is to change the method. The default is `method="inversion"` (the default); then try `method="series"`, `method="interpolation"` and `method="saddlepoint"` in that order. Note that `method="saddlepoint"` is an approximate method only. Also make sure the values in `p.vec` are suitable for the data (see above paragraph).

It is recommended that for the first use with a data set, use `p.vec` with only a small number of values and set `do.smooth=FALSE`, `do.ci=FALSE`. If this is successful, a larger vector `p.vec` and smoothing can be used.

### Author(s)

Peter Dunn (<pdunn2@usc.edu.au>)

### References

- Dunn, P. K. and Smyth, G. K. (2008). Evaluation of Tweedie exponential dispersion model densities by Fourier inversion. *Statistics and Computing*, **18**, 73–86. doi: [10.1007/s1122200790396](https://doi.org/10.1007/s1122200790396)
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- Dunn, Peter K and Smyth, Gordon K (2001). Tweedie family densities: methods of evaluation. *Proceedings of the 16th International Workshop on Statistical Modelling*, Odense, Denmark, 2–6 July
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### See Also

[dtweedie](#), [dtweedie.saddle](#), [tweedie](#)

### Examples

```
library(statmod) # Needed to use tweedie.profile
# Generate some fictitious data
test.data <- rgamma(n = 200, scale = 1, shape = 1)
# The gamma is a Tweedie distribution with power = 2;
# let's see if p = 2 is suggested by tweedie.profile:
## Not run:
out <- tweedie.profile( test.data ~ 1,
p.vec = seq(1.5, 2.5, by = 0.2) )
out$p.max
out$ci

## End(Not run)
```

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