

Package ‘PosRatioDist’

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Type Package

Title Quotient of Random Variables Conditioned to the Positive Quadrant

Version 1.0.1

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Description Computes the exact probability density function of X/Y conditioned on positive quadrant for series of bivariate distributions,for more details see Nadarajah,Song and Si (2019) <[DOI:10.1080/03610926.2019.1576893](https://doi.org/10.1080/03610926.2019.1576893)>.

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License GPL (>= 2)

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dBibs_expPR

*Bibs_expPR***Description**

probability density function of quotient of Balakrishna and Shiji's bivariate exponential random variables conditioned to the positive quadrant. For more detailed information please read the first reference paper.

Usage

```
dBibs_expPR(x, a, r)
```

Arguments

x	vector of positive quantiles.
a	parameter for Balakrishna and Shiji's bivariate exponential distribution
r	parameter for Balakrishna and Shiji's bivariate exponential distribution

Details

Probability density function

$$f_R(r | X > 0, Y > 0) = \frac{a}{2\sqrt{r}} \left(r + \frac{a^2}{4r} \right)^{-3/2}$$

For $r > 0, a > 0$

Value

dBibs_expPR gives the probability density function for quotient of Balakrishna and Shiji's bivariate exponential random variables conditioned to the positive quadrant.

Invalid arguments will return an error message.

References

Yuancheng Si and Saralees Nadarajah and Xiaodong Song, (2020). On the distribution of quotient of random variables conditioned to the positive quadrant. *Communications in Statistics - Theory and Methods*, **49**, pp2514-2528.

Balakrishnan, N. and Lai, C. -D. (2009). *Continuous Bivariate Distributions*. Springer Verlag, New York.

Balakrishna, N. and Shiji, K. (2014). On a class of bivariate exponential distributions. *Statistics and Probability Letters*, **85**, pp153-160.

Examples

```
x <- seq(0.1,5,0.1)
y <- dBibs_expPR(x, 2, 2)
plot(x,y,type = 'l')
```

dBicauchyPR

*BicauchyPR***Description**

probability density function of quotient of Bivariate cauchy random variables conditioned to the positive quadrant. For more detailed information please read the first reference paper.

Usage

```
dBicauchyPR(x, a, b)
```

Arguments

x	single real positive scalar
a	parameter for bivariate cauchy distribution
b	parameter for bivariate cauchy distribution

Details

Probability density function

$$f_R(r | X > 0, Y > 0) = \frac{1}{2\pi \Pr(X > 0, Y > 0)} J_1 \left(r^2 + 1, Ar + B, C, \frac{3}{2} \right)$$

For $-\infty < x < \infty, -\infty < y < \infty, r > 0, -\infty < a < \infty, -\infty < b < \infty$, where $A = -2a, B = -2b, C = 1 + a^2 + b^2$ and J_1 is given by first reference paper section (2.5).

Value

dBicauchyPR gives the probability density function for quotient of Bivariate cauchy random variables conditioned to the positive quadrant.

Invalid arguments will return an error message.

Author(s)

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References

- Yuancheng Si and Saralees Nadarajah and Xiaodong Song, (2020). On the distribution of quotient of random variables conditioned to the positive quadrant. *Communications in Statistics - Theory and Methods*, **49**, pp2514-2528.
- Balakrishnan, N. and Lai, C. -D. (2009). *Continuous Bivariate Distributions*. Springer Verlag, New York.
- Caginalp, C. and Caginalp, G. (2018). The quotient of normal random variables and application to asset price fat tails. *Physica A—Statistical Mechanics and Its Applications*, **499**, pp457-471.
- Louzada, F., Ara, A. and Fernandes, G. (2017). The bivariate alpha-skew-normal distribution. *Communications in Statistics - Theory and Methods*, **46**, pp7147-7156.
- Nadarajah, S. (2009). A bivariate Pareto model for drought. *Stochastic Environmental Research and Risk Assessment*, **23**, pp811-822.
- Nadarajah, S. and Kotz, S. (2006). Reliability models based on bivariate exponential distributions. *Probabilistic Engineering Mechanics*, **21**, pp338-351.
- Nadarajah, S. and Kotz, S. (2007). Financial Pareto ratios. *Quantitative Finance*, **7**, pp257-260.

Examples

```
x <- seq(0.1,5,0.1)
y <- c()
for (i in x){y=c(y,dBicauchyPR(i,1,2))}
plot(x,y,type = 'l')
```

dBiexpweightedPR	<i>BiexpweightedPR</i>
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Description

probability density function of quotient of Bivariate exponential random variables resulting from weighted linear combinations conditioned to the positive quadrant. For more detailed information please read the first reference paper.

Usage

```
dBiexpweightedPR(x, a, b, c)
```

Arguments

- | | |
|---|--|
| x | vector of positive quantiles. |
| a | parameter for Bivariate exponential random variables resulting from weighted linear combinations |

- b parameter for Bivariate exponential random variables resulting from weighted linear combinations
- c parameter for Bivariate exponential random variables resulting from weighted linear combinations

Details

Probability density function

$$f_R(r | X > 0, Y > 0) = \frac{(1 - 2c) \exp [(1 - 2c)a + b]}{\Pr(X > 0, Y > 0) [1 + (1 - 2c)r]^2}$$

For $x > a > -\infty, y > b > -\infty, r > 0, 0 < c < 1$, These correlated exponential random variables can be used to model the stress and strength components of a system, hence the quotient distribution can be used to estimate the probability of failure of the system

Value

dBiexpweightedPR gives the probability density function for quotient of Bivariate exponential random variables resulting from weighted linear combinations conditioned to the positive quadrant.

Invalid arguments will return an error message.

Author(s)

Saralees Nadarajah & Yuancheng Si <siyuanchengman@gmail.com>

References

- Yuancheng Si and Saralees Nadarajah and Xiaodong Song, (2020). On the distribution of quotient of random variables conditioned to the positive quadrant. *Communications in Statistics - Theory and Methods*, **49**, pp2514-2528.
- Balakrishnan, N. and Lai, C. -D. (2009). *Continuous Bivariate Distributions*. Springer Verlag, New York.
- Caginalp, C. and Caginalp, G. (2018). The quotient of normal random variables and application to asset price fat tails. *Physica A—Statistical Mechanics and Its Applications*, **499**, pp457-471.
- Louzada, F., Ara, A. and Fernandes, G. (2017). The bivariate alpha-skew-normal distribution. *Communications in Statistics - Theory and Methods*, **46**, pp7147-7156.
- Nadarajah, S. (2009). A bivariate Pareto model for drought. *Stochastic Environmental Research and Risk Assessment*, **23**, pp811-822.
- Nadarajah, S. and Kotz, S. (2006). Reliability models based on bivariate exponential distributions. *Probabilistic Engineering Mechanics*, **21**, pp338-351.
- Nadarajah, S. and Kotz, S. (2007). Financial Pareto ratios. *Quantitative Finance*, **7**, pp257-260.

Examples

```
x <- seq(0.1,5,0.1)
y <- dBexpweightedPR(x, 4, 2, 0.2)
plot(x,y,type = 'l')
```

dBilomaxPR

BilomaxPR

Description

probability density function of quotient of Bivariate Lomax random variables conditioned to the positive quadrant. For more detailed information please read the first reference paper.

Usage

```
dBilomaxPR(x, a, b, c, alpha, beta, theta)
```

Arguments

x	single positive scalar for quotient
a	parameter for Bivariate lomax distribution
b	parameter for Bivariate lomax distribution
c	parameter for Bivariate lomax distribution
alpha	parameter for Bivariate lomax distribution
beta	parameter for Bivariate lomax distribution
theta	parameter for Bivariate lomax distribution

Details

Probability density function

$$f_R(r | X > 0, Y > 0) = \frac{c^2 \theta^2 r}{\Pr(X > 0, Y > 0)} J_3(\theta r, \beta - \theta a + (\alpha - \theta b)r, 1 - \alpha a - \beta b + \theta ab, c + 2) + \frac{c^2 \theta [(\alpha - \theta b)r + \beta]}{\Pr(X > 0, Y > 0)}$$

For $r > 0, \alpha > 0, \beta > 0, \theta > 0, 0 \leq \theta \leq (c + 1)\alpha\beta$ where J_1, J_2, J_3 are given by first reference paper section (2.5)

Value

dBilomaxPR gives the probability density function for bivariate lomax random variables conditioned to the positive quadrant.

Invalid arguments will return an error message.

Author(s)

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References

Yuancheng Si and Saralees Nadarajah and Xiaodong Song, (2020). On the distribution of quotient of random variables conditioned to the positive quadrant. *Communications in Statistics - Theory and Methods*, **49**, pp2514-2528.

Balakrishnan, N. and Lai, C. -D. (2009). *Continuous Bivariate Distributions*. Springer Verlag, New York.

dBiMG_expPR

BiMG_expPR

Description

probability density function of quotient of Morgenstern type bivariate exponential random variables conditioned to the positive quadrant. For more detailed information please read the first reference paper.

Usage

dBiMG_expPR(x, a, b, alpha)

Arguments

x	vector of positive quantiles.
a	parameter for Morgenstern type bivariate exponential distribution
b	parameter for Morgenstern type bivariate exponential distribution
alpha	parameter for Morgenstern type bivariate exponential distribution

Details

Probability density function

$$f_R(r | X > 0, Y > 0) = \frac{(1 + \alpha) \exp(a + b)}{\Pr(X > 0, Y > 0)(1 + r)^2} - \frac{2\alpha \exp(a + 2b)}{\Pr(X > 0, Y > 0)(2 + r)^2} - \frac{2\alpha \exp(2a + b)}{\Pr(X > 0, Y > 0)(1 + 2r)^2} + \frac{\alpha^2 \exp(a + b)}{\Pr(X > 0, Y > 0)}$$

For $r > 0, -1 \leq \alpha \leq 1, a > -\infty, b > -\infty$ These correlated exponential random variables can also be used to model the stress and strength components of a system, hence the quotient distribution can be used to estimate the probability of failure of the system

Value

dBiMG_expPR gives the probability density function for quotient of Morgenstern type bivariate exponential random variables conditioned to the positive quadrant

Invalid arguments will return an error message.

Author(s)

Saralees Nadarajah & Yuancheng Si <siyuanchengman@gmail.com>

References

Yuancheng Si and Saralees Nadarajah and Xiaodong Song, (2020). On the distribution of quotient of random variables conditioned to the positive quadrant. *Communications in Statistics - Theory and Methods*, **49**, pp2514-2528.

Balakrishnan, N. and Lai, C. -D. (2009). *Continuous Bivariate Distributions*. Springer Verlag, New York.

Balakrishna, N. and Shiji, K. (2014). On a class of bivariate exponential distributions. *Statistics and Probability Letters*, **85**, pp153-160.

Examples

```
x <- seq(0.1,5,0.1)
y <- dBIMG_expPR(x, 3, 2, 0.5)
plot(x,y,type = 'l')
```

dBinormalPR

BinormalPR

Description

probability density function of quotient of Bivariate normal random variables conditioned to the positive quadrant. For more detailed information please read the first reference paper.

Usage

```
dBinormalPR(x, a, b, rho)
```

Arguments

x	vector of positive quantiles.
a	parameter
b	parameter
rho	correlation coefficient, $-1 < \rho < 1$

Details

Probability density function

$$f_R(r | X > 0, Y > 0) = \frac{1}{2\pi\sqrt{1-\rho^2} \Pr(X > 0, Y > 0)} \exp\left[-\frac{a^2 + b^2 - 2\rho ab}{2(1-\rho^2)}\right] I_1\left(\frac{1 + Cr + r^2}{2(1-\rho^2)}, \frac{Ar + B}{2(1-\rho^2)}\right)$$

For $-\infty < x < \infty, -\infty < y < \infty, r > 0, -\infty < a < \infty, -\infty < b < \infty, -1 < \rho < 1$, where $A = -2a + 2\rho b, B = -2b + 2\rho a, C = -2\rho$

Value

dBinormalPR gives the probability density function for quotient of Bivariate normal random variables conditioned to the positive quadrant.

Invalid arguments will return an error message.

Author(s)

Saralees Nadarajah & Yuancheng Si <siyuanchengman@gmail.com>

References

Yuancheng Si and Saralees Nadarajah and Xiaodong Song, (2020). On the distribution of quotient of random variables conditioned to the positive quadrant. *Communications in Statistics - Theory and Methods*, **49**, pp2514-2528.

Balakrishna, N. and Shiji, K. (2014). On a class of bivariate exponential distributions. *Statistics and Probability Letters*, **85**, pp153-160.

Arnold, B. C. and Strauss, D. (1988). Pseudolikelihood estimation. *Sankhya B*, **53**, pp233-243.

Caginalp, C. and Caginalp, G. (2018). The quotient of normal random variables and application to asset price fat tails. *Physica A—Statistical Mechanics and Its Applications*, **499**, pp457-471.

Louzada, F., Ara, A. and Fernandes, G. (2017). The bivariate alpha-skew-normal distribution. *Communications in Statistics - Theory and Methods*, **46**, pp7147-7156.

Nadarajah, S. (2009). A bivariate Pareto model for drought. *Stochastic Environmental Research and Risk Assessment*, **23**, pp811-822.

Nadarajah, S. and Kotz, S. (2006). Reliability models based on bivariate exponential distributions. *Probabilistic Engineering Mechanics*, **21**, pp338-351.

Nadarajah, S. and Kotz, S. (2007). Financial Pareto ratios. *Quantitative Finance*, **7**, pp257-260.

Examples

```
x <- seq(0.1,5,0.1)
y <- dBinormalPR(x, 2, 1, 0.5)
plot(x,y,type = 'l')
```

 dBiparetoPR

BiparetoPR

Description

probability density function of quotient of Bivariate Pareto random variables conditioned to the positive quadrant. For more detailed information please read the first reference paper.

Usage

dBiparetoPR(x)

Arguments

x vector of positive quantiles.

Details

Probability density function

$$f_R(r | X > 0, Y > 0) = (r + 1)^{-2}$$

For $r > 0$, Nadarajah (2009) used this distribution to model the proportion of droughts defined as a quotient of drought durations and non-drought durations.

Value

dBiparetoPR gives the probability density function for quotient of Bivariate Pareto random variables conditioned to the positive quadrant.

Invalid arguments will return an error message.

Author(s)

Saralees Nadarajah & Yuancheng Si <siyuanchengman@gmail.com>

References

Yuancheng Si and Saralees Nadarajah and Xiaodong Song, (2020). On the distribution of quotient of random variables conditioned to the positive quadrant. *Communications in Statistics - Theory and Methods*, **49**, pp2514-2528.

Mardia, K. V. (1962). Multivariate Pareto distributions. *Annals of Mathematical Statistics*, **33**, 1008-1015.

Nadarajah, S. (2009) A bivariate Pareto model for drought. *Stochastic Environmental Research and Risk Assessment*, **23**, pp811-822.

Examples

```
x <- seq(0.1, 5, 0.1)
y <- dBiparetoPR(x)
plot(x, y, type = 'l')
```

dBitPR

BitPR

Description

probability density function of quotient of Bivariate t random variables conditioned to the positive quadrant. For more detailed information please read the first reference paper.

Usage

dBitPR(x, a, b, rho, v)

Arguments

x	single positive scalar, for quotient of Bivariate t random variables conditioned to the positive quadrant
a	parameter for Bivariate t distribution
b	parameter for Bivariate t distribution
rho	correlation coefficient, $-1 < \rho < 1$
v	parameter, degree of freedom of Bivariate t distribution

Details

Probability density function

$$f_R(r | X > 0, Y > 0) = \frac{\Gamma\left(\frac{\nu+2}{2}\right) \nu^{\frac{\nu}{2}} (1-\rho^2)^{\frac{\nu+1}{2}}}{\Gamma\left(\frac{\nu}{2}\right) \pi \Pr(X > 0, Y > 0)} J_1\left(r^2 - 2\rho r + 1, Ar + B, C + \nu(1-\rho^2), \frac{\nu}{2} + 1\right)$$

For $-\infty < x < \infty, -\infty < y < \infty, r > 0, -\infty < a < \infty, -\infty < b < \infty, -1 < \rho < 1$, where $A = -2a + 2\rho b, B = -2b + 2\rho a, C = a^2 + b^2 - 2\rho ab$ and J_1 is given by first reference paper section (2.5).

Value

dBitPR gives the probability density function for quotient of Bivariate t random variables conditioned to the positive quadrant.

Invalid arguments will return an error message.

Author(s)

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References

- Yuancheng Si and Saralees Nadarajah and Xiaodong Song, (2020). On the distribution of quotient of random variables conditioned to the positive quadrant. *Communications in Statistics - Theory and Methods*, **49**, pp2514-2528.
- Balakrishnan, N. and Lai, C. -D. (2009). *Continuous Bivariate Distributions*. Springer Verlag, New York.
- Arnold, B. C. and Strauss, D. (1988). Pseudolikelihood estimation. *Sankhya B*, **53**, pp233-243.
- Caginalp, C. and Caginalp, G. (2018). The quotient of normal random variables and application to asset price fat tails. *Physica A—Statistical Mechanics and Its Applications*, **499**, pp457-471.
- Louzada, F., Ara, A. and Fernandes, G. (2017). The bivariate alpha-skew-normal distribution. *Communications in Statistics - Theory and Methods*, **46**, pp7147-7156.
- Nadarajah, S. (2009). A bivariate Pareto model for drought. *Stochastic Environmental Research and Risk Assessment*, **23**, pp811-822.
- Nadarajah, S. and Kotz, S. (2006). Reliability models based on bivariate exponential distributions. *Probabilistic Engineering Mechanics*, **21**, pp338-351.
- Nadarajah, S. and Kotz, S. (2007). Financial Pareto ratios. *Quantitative Finance*, **7**, pp257-260.

Examples

```
x <- seq(0.1, 5, 0.1)
y <- c()
for (i in x){y=c(y, dBitPR(i, 1, 2, 0.5, 2))}
plot(x, y, type = 'l')
```

I_1

Lemma

Description

Technical Lemmas for calculating quotient of random variables conditioned to the positive quadrant. For more detailed information please read the first reference paper section 2.2.

Usage

I_1(a, b)

I_2(a, b)

I_3(a, b)

J_1(a, b, c, alpha)

J_2(a, b, c, alpha)

J_3(a, b, c, alpha)

Arguments

a	parameter
b	parameter
c	parameter
alpha	parameter

Details

I_n Type I Integration

$$I_n(a, b) = \int_0^{\infty} y^n \exp(-ay^2 - by) dy$$

For $-\infty < a < \infty$, $-\infty < b < \infty$, where n is positive integer.

In particular, for $a > 0$, we have expressions below

$$I_1(a, b) = -\frac{\sqrt{\pi}b}{4a^{3/2}} \exp\left(\frac{b^2}{4a}\right) \operatorname{erfc}\left(\frac{b}{2\sqrt{a}}\right) + \frac{1}{2a}$$

$$I_2(a, b) = \frac{\sqrt{\pi}}{4a^{3/2}} \exp\left(\frac{b^2}{4a}\right) \operatorname{erfc}\left(\frac{b}{2\sqrt{a}}\right) + \frac{\sqrt{\pi}b^2}{8a^{5/2}} \exp\left(\frac{b^2}{4a}\right) \operatorname{erfc}\left(\frac{b}{2\sqrt{a}}\right) - \frac{b}{4a^2}$$

$$I_3(a, b) = -\frac{3\sqrt{\pi}b}{8a^{5/2}} \exp\left(\frac{b^2}{4a}\right) \operatorname{erfc}\left(\frac{b}{2\sqrt{a}}\right) - \frac{\sqrt{\pi}b^3}{16a^{7/2}} \exp\left(\frac{b^2}{4a}\right) \operatorname{erfc}\left(\frac{b}{2\sqrt{a}}\right) + \frac{1}{2a^2} + \frac{b^2}{8a^3}$$

J_n Type J Integration

$$J_n(a, b, c, \alpha) = \int_0^{\infty} y^n (ay^2 + by + c)^{-\alpha} dy$$

In particular, for $a > 0$, $b^2 < 4ac$, $-1 < n < 2\alpha - 1$, we have expressions below

$$J_1(a, b, c, \alpha) = a^{-1}c^{1-\alpha} B(2, 2\alpha - 2) {}_2F_1\left(1, \alpha - 1; \alpha + \frac{1}{2}; 1 - \frac{b^2}{4ac}\right)$$

$$J_2(a, b, c, \alpha) = a^{-\frac{3}{2}}c^{\frac{3}{2}-\alpha} B(3, 2\alpha - 3) {}_2F_1\left(\frac{3}{2}, \alpha - \frac{3}{2}; \alpha + \frac{1}{2}; 1 - \frac{b^2}{4ac}\right)$$

$$J_3(a, b, c, \alpha) = a^{-2}c^{2-\alpha} B(4, 2\alpha - 4) {}_2F_1\left(2, \alpha - 2; \alpha + \frac{1}{2}; 1 - \frac{b^2}{4ac}\right)$$

Value

I_1 gives value of Type I integration with $n = 1$

I_2 gives value of Type I integration with $n = 2$

I_3 gives value of Type I integration with $n = 3$

J_1 gives value of Type J integration with $n = 1$

J_2 gives value of Type J integration with $n = 2$

J_3 gives value of Type J integration with $n = 3$

Invalid arguments will return an error message.

Author(s)

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References

- Yuancheng Si and Saralees Nadarajah and Xiaodong Song, (2020). On the distribution of quotient of random variables conditioned to the positive quadrant. *Communications in Statistics - Theory and Methods*, **49**, pp2514-2528.
- Balakrishna, N. and Shiji, K. (2014). On a class of bivariate exponential distributions. *Statistics and Probability Letters*, **85**, pp153-160.
- Arnold, B. C. and Strauss, D. (1988). Pseudolikelihood estimation. *Sankhya B*, **53**, pp233-243.
- Caginalp, C. and Caginalp, G. (2018). The quotient of normal random variables and application to asset price fat tails. *Physica A—Statistical Mechanics and Its Applications*, **499**, pp457-471.
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- Nadarajah, S. and Kotz, S. (2007). Financial Pareto ratios. *Quantitative Finance*, **7**, pp257-260.

Examples

I_1(1, 2)
I_2(1, 2)
I_3(1, 2)
J_1(1, 2, 3, 3)
J_2(1, 2, 3, 3)
J_3(1, 2, 3, 3)

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