

Factsheet: Gamma distribution

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Summary

A factsheet for the gamma distribution.

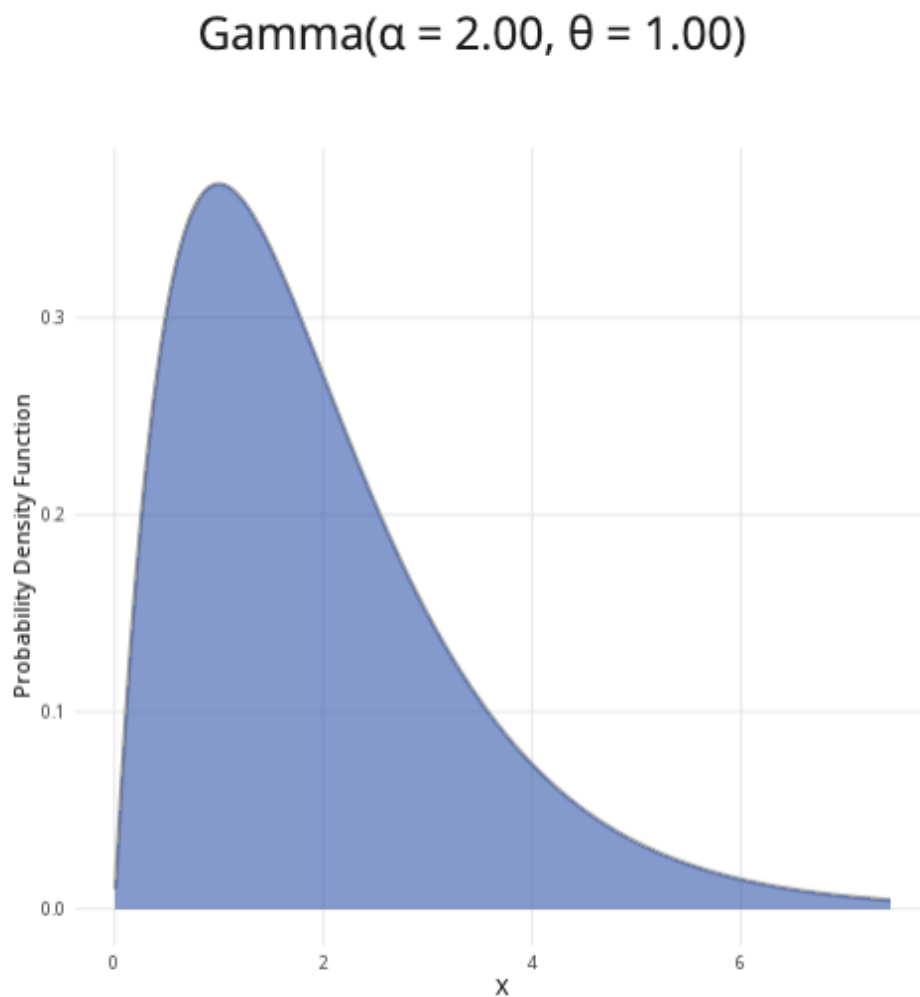


Figure 1: An example of the gamma distribution with $\alpha = 2$ and $\theta = 1$.

Where to use: The gamma distribution generalizes the exponential distribution, allowing for greater or lesser variance. It is used to model positive continuous random variables that have skewed distributions.

Notation: $X \sim \text{Gamma}(\alpha, \theta)$ or $X \sim \text{Gam}(\alpha, \theta)$

Parameters: Two real numbers α and θ , which are related to the mean μ and variance σ^2 :

- $\alpha = \frac{\mu^2}{\sigma^2}$ (shape parameter)
- $\theta = \frac{\sigma^2}{\mu}$ (scale parameter)

| Quantity | Value | Notes |
|-----------------|--|---|
| Mean | $\mathbb{E}(X) = \alpha\theta$ | |
| Variance | $\mathbb{V}(X) = \alpha\theta^2$ | |
| PDF | $\mathbb{P}(X = x) = \frac{x^{\alpha-1} \exp(-\frac{x}{\theta})}{\Gamma(\alpha)\theta^\alpha}$ | $\Gamma(x)$ the gamma function of x |
| CDF | $\mathbb{P}(X \leq x) = \frac{\text{Gam}(\alpha, \frac{x}{\theta})}{\Gamma(\alpha)}$ | $\text{Gam}(\alpha, \theta)$ is the PDF of the gamma distribution |

Example: You collect historical data on the time to failure of a machine from Cantor's Confectionery. The mean is 83 days and the variance is 50.3. You can then use this to estimate the shape and scale parameters of the gamma distribution:

- $\alpha = \frac{83^2}{50.3} = 136.958250497 \approx 137$
- $\theta = \frac{50.3}{83} = 0.60602409638 \approx 0.61$

The distribution can be expressed as $X \sim \text{Gam}(137, 0.61)$, where the shape parameter is 137 and the scale parameter is 0.61.

Further reading

This interactive element appears in [Overview: Probability distributions](#). Please click this link to go to the guide.

Version history

v1.0: initial version created 04/25 by tdhc and Michelle Arnetta as part of a University of St Andrews VIP project.

- v1.1: moved to factsheet form and populated with material from [Overview: Probability distributions](#) by tdhc.

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