

## ladder — Ladder of powers

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## Syntax

*Ladder of powers*

```
ladder varname [if] [in] [, generate(newvar) noadjust]
```

*Ladder-of-powers histograms*

```
gladder varname [if] [in] [, histogram_options combine_options]
```

*Ladder-of-powers quantile-normal plots*

```
qladder varname [if] [in] [, qnorm_options combine_options]
```

*by* is allowed with `ladder`; see [\[D\] by](#).

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## Description

`ladder` searches a subset of the ladder of powers (Tukey 1977) for a transform that converts *varname* into a normally distributed variable. `sktest` tests for normality; see [\[R\] sktest](#). Also see [\[R\] boxcox](#).

`gladder` displays nine histograms of transforms of *varname* according to the ladder of powers. `gladder` is useful pedagogically, but we do not advise looking at histograms for research work; `ladder` or `qnorm` (see [\[R\] diagnostic plots](#)) is preferred.

`qladder` displays the quantiles of transforms of *varname* according to the ladder of powers against the quantiles of a normal distribution.

## Options for ladder

Main

`generate(newvar)` saves the transformed values corresponding to the minimum chi-squared value from the table. We do not recommend using `generate()` because it is literal in interpreting the minimum, thus ignoring nearly equal but perhaps more interpretable transforms.

`roadjust` is the `roadjust` option to `sktest`; see [R] [sktest](#).

## Options for gladder

*histogram\_options* affect the rendition of the histograms across all relevant transformations; see [R] [histogram](#). Here the `normal` option is assumed, so you must supply the `nonnormal` option to suppress the overlaid normal density. Also, `gladder` does not allow the `width(#)` option of `histogram`.

*combine\_options* are any of the options documented in [G-2] [graph combine](#). These include options for titling the graph (see [G-3] [title\\_options](#)) and for saving the graph to disk (see [G-3] [saving\\_option](#)).

## Options for qladder

*qnorm\_options* affect the rendition of the quantile–normal plots across all relevant transformations. See [R] [diagnostic plots](#).

*combine\_options* are any of the options documented in [G-2] [graph combine](#). These include options for titling the graph (see [G-3] [title\\_options](#)) and for saving the graph to disk (see [G-3] [saving\\_option](#)).

## Remarks and examples

[stata.com](http://www.stata.com)

### ▷ Example 1: ladder

We have data on the mileage rating of 74 automobiles and wish to find a transform that makes the variable normally distributed:

```
. use http://www.stata-press.com/data/r13/auto
(1978 Automobile Data)
. ladder mpg
```

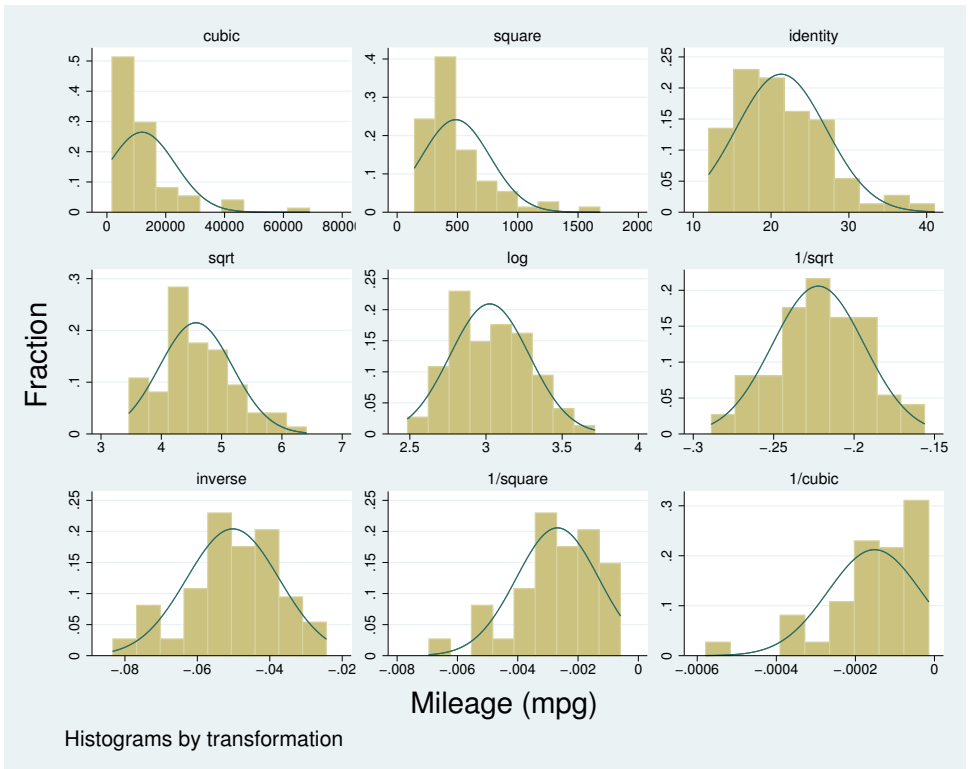
Transformation	formula	chi2(2)	P(chi2)
cubic	$mpg^3$	43.59	0.000
square	$mpg^2$	27.03	0.000
identity	$mpg$	10.95	0.004
square root	$\sqrt{mpg}$	4.94	0.084
log	$\log(mpg)$	0.87	0.647
1/(square root)	$1/\sqrt{mpg}$	0.20	0.905
inverse	$1/mpg$	2.36	0.307
1/square	$1/(mpg^2)$	11.99	0.002
1/cubic	$1/(mpg^3)$	24.30	0.000

If we had typed `ladder mpg, gen(mpgx)`, the variable `mpgx` containing  $1/\sqrt{mpg}$  would have been automatically generated for us. This is the perfect example of why you should not, in general, specify the `generate()` option. We also cannot reject the hypothesis that the inverse of `mpg` is normally distributed and that  $1/mpg$ —gallons per mile—has a better interpretation. It is a measure of energy consumption.

## Example 2: gladder

gladder explores the same transforms as ladder but presents results graphically:

```
. gladder mpg, fraction
```



◀

## Technical note

gladder is useful pedagogically, but be careful when using it for research work, especially with many observations. For instance, consider the following data on the average July temperature in degrees Fahrenheit for 954 U.S. cities:

```
. use http://www.stata-press.com/data/r13/citytemp
(City Temperature Data)
. ladder tempjuly
```

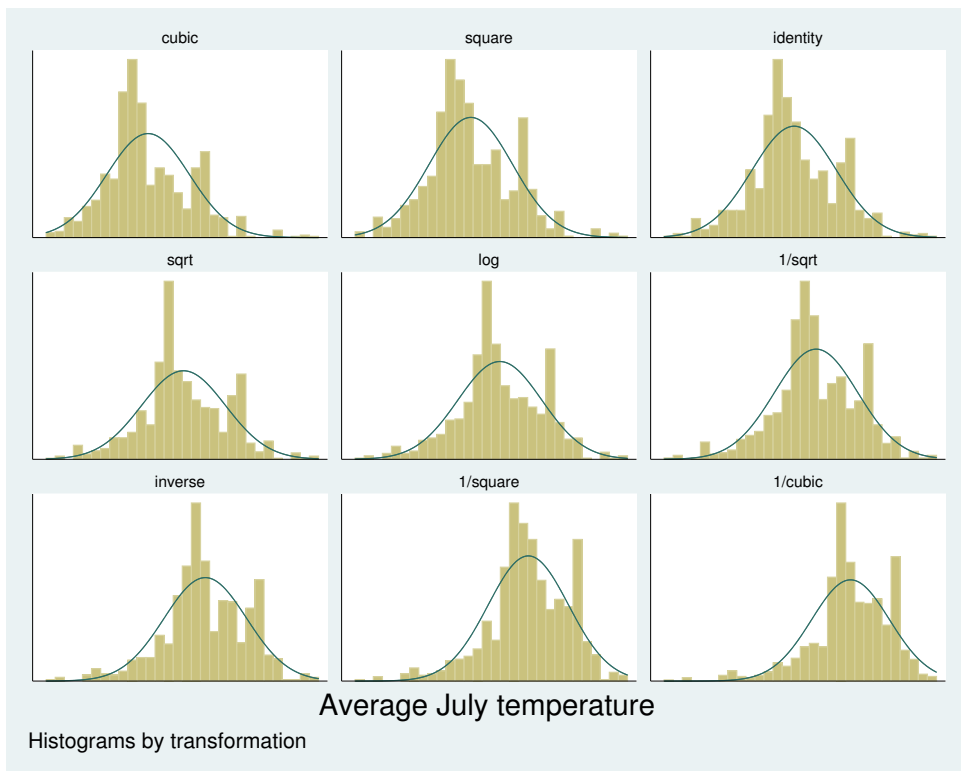
Transformation	formula	chi2(2)	P(chi2)
cubic	tempjuly^3	47.49	0.000
square	tempjuly^2	19.70	0.000
identity	tempjuly	3.83	0.147
square root	sqrt(tempjuly)	1.83	0.400
log	log(tempjuly)	5.40	0.067
1/(square root)	1/sqrt(tempjuly)	13.72	0.001
inverse	1/tempjuly	26.36	0.000
1/square	1/(tempjuly^2)	64.43	0.000
1/cubic	1/(tempjuly^3)	.	0.000

The period in the last line indicates that the  $\chi^2$  is very large; see [\[R\] sktest](#).

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From the table, we see that there is certainly a difference in normality between the square and square-root transform. If, however, you can see the difference between the transforms in the diagram below, you have better eyes than we do:

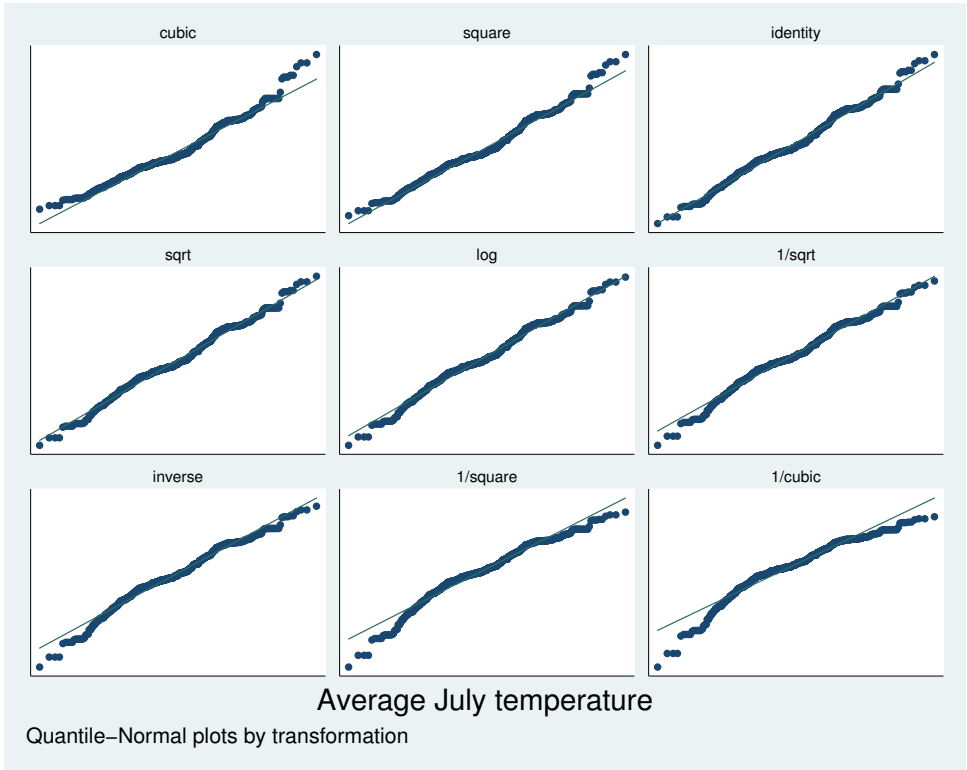
```
. gladder tempjuly, l1title("") ylabel(none) xlabel(none)
```



### ▷ Example 3: qladder

A better graph for seeing normality is the quantile–normal graph, which can be produced by `qladder`.

```
. qladder tempjuly, ylabel(none) xlabel(none)
```



This graph shows that for the square transform, the upper tail—and only the upper tail—diverges from what would be expected. This divergence is detected by `sktest` (see [R] [sktest](#)) as a problem with skewness, as we would learn from using `sktest` to examine `tempjuly` squared and square rooted.

## Stored results

`ladder` stores the following in `r()`:

Scalars

<code>r(N)</code>	number of observations
<code>r(invcube)</code>	$\chi^2$ for inverse-cubic transformation
<code>r(P_invcube)</code>	significance level for inverse-cubic transformation
<code>r(invsq)</code>	$\chi^2$ for inverse-square transformation
<code>r(P_invsq)</code>	significance level for inverse-square transformation
<code>r(inv)</code>	$\chi^2$ for inverse transformation
<code>r(P_inv)</code>	significance level for inverse transformation
<code>r(invsqrt)</code>	$\chi^2$ for inverse-root transformation
<code>r(P_invsqrt)</code>	significance level for inverse-root transformation
<code>r(log)</code>	$\chi^2$ for log transformation
<code>r(P_log)</code>	significance level for log transformation
<code>r(sqrt)</code>	$\chi^2$ for square-root transformation
<code>r(P_sqrt)</code>	significance level for square-root transformation
<code>r(ident)</code>	$\chi^2$ for untransformed data
<code>r(P_ident)</code>	significance level for untransformed data
<code>r(square)</code>	$\chi^2$ for square transformation
<code>r(P_square)</code>	significance level for square transformation
<code>r(cube)</code>	$\chi^2$ for cubic transformation
<code>r(P_cube)</code>	significance level for cubic transformation

## Methods and formulas

For `ladder`, results are as reported by `sktest`; see [R] [sktest](#). If `generate()` is specified, the transform with the minimum  $\chi^2$  value is chosen.

`gladder` sets the number of bins to  $\min(\sqrt{n}, 10 \log_{10} n)$ , rounded to the closest integer, where  $n$  is the number of unique values of `varname`. See [R] [histogram](#) for a discussion of the optimal number of bins.

Also see [Findley \(1990\)](#) for a ladder-of-powers variable transformation program that produces one-way graphs with overlaid box plots, in addition to histograms with overlaid normals. [Buchner and Findley \(1990\)](#) discuss ladder-of-powers transformations as one aspect of preliminary data analysis. Also see [Hamilton \(1992, 18–23\)](#) and [Hamilton \(2013, 129–132\)](#).

## Acknowledgment

`qladder` was written by Jeroen Weesie of the Department of Sociology at Utrecht University, The Netherlands.

## References

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- Tukey, J. W. 1977. *Exploratory Data Analysis*. Reading, MA: Addison–Wesley.

## Also see

- [R] [diagnostic plots](#) — Distributional diagnostic plots
- [R] [lnskew0](#) — Find zero-skewness log or Box–Cox transform
- [R] [lv](#) — Letter-value displays
- [R] [sktest](#) — Skewness and kurtosis test for normality