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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.

`gladder` and `qladder` each display a graph matrix. `gladder` displays nine histograms of transforms of *varname* according to the ladder of powers. `qladder` displays the quantiles of transforms of *varname* according to the ladder of powers against the quantiles of a normal distribution.

## Quick start

Table showing Tukey's ladder of powers transformations for *v*

```
ladder v
```

Same as above, but with separate tables for each level of the categorical variable *catvar*

```
by catvar: ladder v
```

Display transformations graphically using histograms

```
gladder v
```

Same as above, but using quantile plots

```
qladder v
```

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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 and collect are allowed with ladder; see [U] **11.1.10 Prefix commands**.

## Options for ladder

Main

`generate(newvar)` saves the transformed values corresponding to the minimum  $\chi^2$  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.

`noadjust` is the `noadjust` 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

### ▷ 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 https://www.stata-press.com/data/r18/auto
(1978 automobile data)
. ladder mpg
```

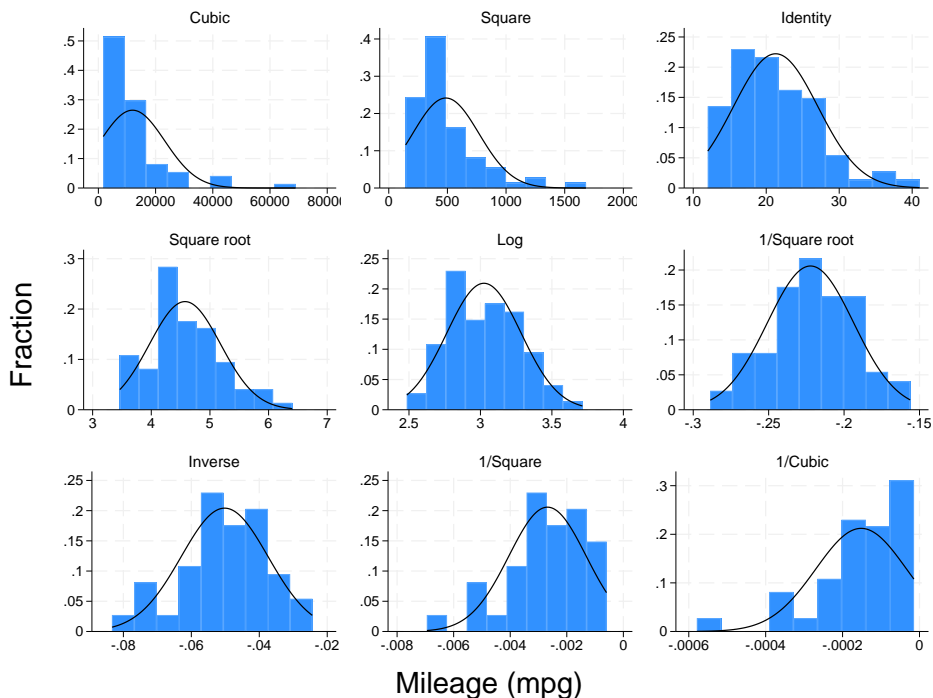
| Transformation  | Formula               | chi2(2) | Prob > chi2 |
|-----------------|-----------------------|---------|-------------|
| Cubic           | $\text{mpg}^3$        | 43.59   | 0.000       |
| Square          | $\text{mpg}^2$        | 27.03   | 0.000       |
| Identity        | $\text{mpg}$          | 10.95   | 0.004       |
| Square root     | $\sqrt{\text{mpg}}$   | 4.94    | 0.084       |
| Log             | $\log(\text{mpg})$    | 0.87    | 0.647       |
| 1/(Square root) | $1/\sqrt{\text{mpg}}$ | 0.20    | 0.905       |
| Inverse         | $1/\text{mpg}$        | 2.36    | 0.307       |
| 1/Square        | $1/(\text{mpg}^2)$    | 11.99   | 0.002       |
| 1/Cubic         | $1/(\text{mpg}^3)$    | 24.30   | 0.000       |

If we had typed `ladder mpg, gen(mpgx)`, the variable `mpgx` containing  $1/\sqrt{\text{mpg}}$  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  $1/\text{mpg}$ —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
```



Histograms by transformation



□ Technical note

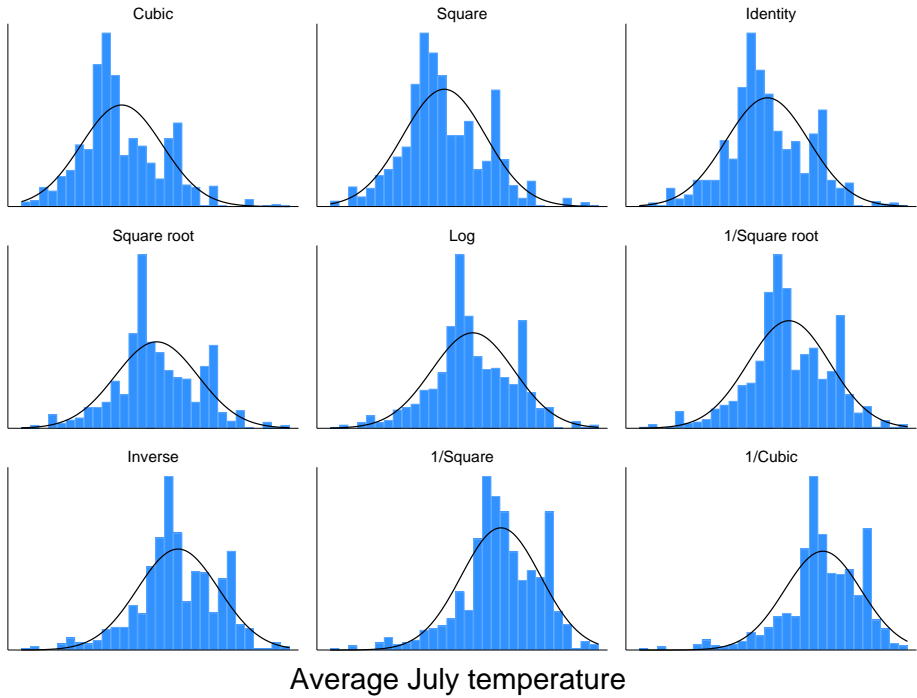
gladder is useful pedagogically, but be careful when using it for research work, especially with many observations. For instance, consider the following data on the average July temperature in degrees Fahrenheit for 954 U.S. cities:

```
. use https://www.stata-press.com/data/r18/citytemp
(City temperature data)
. ladder tempjuly
```

| Transformation  | Formula                    | chi2(2) | Prob > chi2 |
|-----------------|----------------------------|---------|-------------|
| Cubic           | tempjuly <sup>3</sup>      | 47.49   | 0.000       |
| Square          | tempjuly <sup>2</sup>      | 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 <sup>2</sup> ) | 64.44   | 0.000       |
| 1/Cubic         | 1/(tempjuly <sup>3</sup> ) | 116.16  | 0.000       |

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)
```



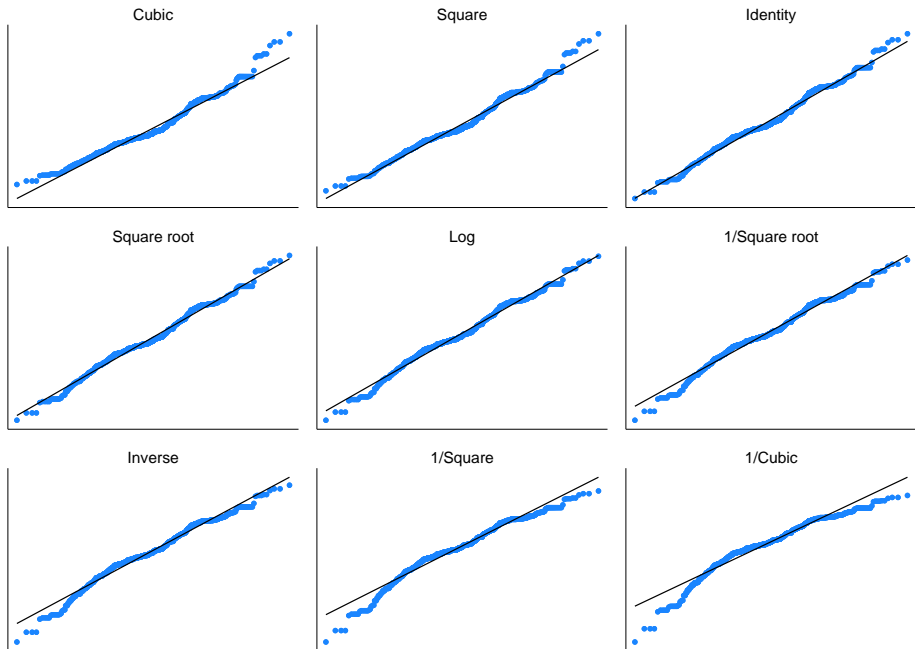
Histograms by transformation



### ► 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)
```



Average July temperature

Quantile-normal plots by transformation

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 `tempjuly squared` 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> | $p$ -value for normality test after inverse-cubic transformation  |
| <code>r(invsq)</code>     | $\chi^2$ for inverse-square transformation                        |
| <code>r(P_invsq)</code>   | $p$ -value for normality test after inverse-square transformation |
| <code>r(inv)</code>       | $\chi^2$ for inverse transformation                               |
| <code>r(P_inv)</code>     | $p$ -value for normality test after inverse transformation        |
| <code>r(invsqrt)</code>   | $\chi^2$ for inverse-root transformation                          |
| <code>r(P_invsqrt)</code> | $p$ -value for normality test after inverse-root transformation   |
| <code>r(log)</code>       | $\chi^2$ for log transformation                                   |
| <code>r(P_log)</code>     | $p$ -value for normality test after log transformation            |
| <code>r(sqrt)</code>      | $\chi^2$ for square-root transformation                           |
| <code>r(P_sqrt)</code>    | $p$ -value for normality test after square-root transformation    |
| <code>r(ident)</code>     | $\chi^2$ for untransformed data                                   |
| <code>r(P_ident)</code>   | $p$ -value for normality test of untransformed data               |
| <code>r(square)</code>    | $\chi^2$ for square transformation                                |
| <code>r(P_square)</code>  | $p$ -value for normality test after square transformation         |
| <code>r(cube)</code>      | $\chi^2$ for cubic transformation                                 |
| <code>r(P_cube)</code>    | $p$ -value for normality test after 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

- Buchner, D. M., and T. W. Findley. 1990. Research in physical medicine and rehabilitation: VIII. Preliminary data analysis. *American Journal of Physical Medicine and Rehabilitation* 69: 154–169. <https://doi.org/10.1097/00002060-199006000-00011>.
- Cox, N. J. 2005. [Speaking Stata: Density probability plots](#). *Stata Journal* 5: 259–273.
- Findley, T. W. 1990. [sed3: Variable transformation and evaluation](#). *Stata Technical Bulletin* 2: 15. Reprinted in *Stata Technical Bulletin Reprints*, vol. 1, pp. 85–86. College Station, TX: Stata Press.
- Hamilton, L. C. 1992. *Regression with Graphics: A Second Course in Applied Statistics*. Belmont, CA: Duxbury.
- . 2013. *Statistics with Stata: Updated for Version 12*. 8th ed. Boston: Brooks/Cole.
- Tukey, J. W. 1977. *Exploratory Data Analysis*. Reading, MA: Addison–Wesley.

## Also see

[R] **boxcox** — Box–Cox regression models

[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 tests for normality

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