Title

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logistic — Logistic regression, reporting odds ratios

Syntax

`logistic` *depvar indepvars* [*if*] [*in*] [*weight*] [, *options*]

options	Description
Model	
`noconstant`	suppress constant term
`offset(`*varname*`)`	include *varname* in model with coefficient constrained to 1
`asis`	retain perfect predictor variables
`constraints(`*constraints*`)`	apply specified linear constraints
`collinear`	keep collinear variables
SE/Robust	
`vce(`*vcetype*`)`	*vcetype* may be `oim`, `robust`, `cluster` *clustvar*, `bootstrap`, or `jackknife`
Reporting	
`level(`*#*`)`	set confidence level; default is `level(95)`
`coef`	report estimated coefficients
`nocnsreport`	do not display constraints
display_options	control column formats, row spacing, line width, display of omitted variables and base and empty cells, and factor-variable labeling
Maximization	
maximize_options	control the maximization process; seldom used
`coeflegend`	display legend instead of statistics

indepvars may contain factor variables; see **[U] 11.4.3 Factor variables**.

depvar and *indepvars* may contain time-series operators; see **[U] 11.4.4 Time-series varlists**.

`bootstrap`, `by`, `fp`, `jackknife`, `mfp`, `mi estimate`, `nestreg`, `rolling`, `statsby`, `stepwise`, and `svy` are allowed; see **[U] 11.1.10 Prefix commands**.

`vce(bootstrap)` and `vce(jackknife)` are not allowed with the `mi estimate` prefix; see **[MI] mi estimate**.

Weights are not allowed with the `bootstrap` prefix; see **[R] bootstrap**.

`vce()` and weights are not allowed with the `svy` prefix; see **[SVY] svy**.

`fweight`s, `iweight`s, and `pweight`s are allowed; see **[U] 11.1.6 weight**.

`coeflegend` does not appear in the dialog box.

See **[U] 20 Estimation and postestimation commands** for more capabilities of estimation commands.

Menu

Statistics > Binary outcomes > Logistic regression (reporting odds ratios)

Description

`logistic` fits a logistic regression model of *depvar* on *indepvars*, where *depvar* is a 0/1 variable (or, more precisely, a 0/non-0 variable). Without arguments, `logistic` redisplays the last `logistic` estimates. `logistic` displays estimates as odds ratios; to view coefficients, type `logit` after running `logistic`. To obtain odds ratios for any covariate pattern relative to another, see [R] **lincom**.

Options

Model

`noconstant`, `offset(`*varname*`)`, `constraints(`*constraints*`)`, `collinear`; see [R] **estimation options**.

`asis` forces retention of perfect predictor variables and their associated perfectly predicted observations and may produce instabilities in maximization; see [R] **probit**.

SE/Robust

`vce(`*vcetype*`)` specifies the type of standard error reported, which includes types that are derived from asymptotic theory (`oim`), that are robust to some kinds of misspecification (`robust`), that allow for intragroup correlation (`cluster` *clustvar*), and that use bootstrap or jackknife methods (`bootstrap`, `jackknife`); see [R] ***vce_option***.

Reporting

`level(`*#*`)`; see [R] **estimation options**.

`coef` causes `logistic` to report the estimated coefficients rather than the odds ratios (exponentiated coefficients). `coef` may be specified when the model is fit or may be used later to redisplay results. `coef` affects only how results are displayed and not how they are estimated.

`nocnsreport`; see [R] **estimation options**.

display_options: `noomitted`, `vsquish`, `noemptycells`, `baselevels`, `allbaselevels`, `nofvlabel`, `fvwrap(`*#*`)`, `fvwrapon(`*style*`)`, `cformat(`*%fmt*`)`, `pformat(`*%fmt*`)`, `sformat(`*%fmt*`)`, and `nolstretch`; see [R] **estimation options**.

Maximization

maximize_options: `difficult`, `technique(`*algorithm_spec*`)`, `iterate(`*#*`)`, `[no]log`, `trace`, `gradient`, `showstep`, `hessian`, `showtolerance`, `tolerance(`*#*`)`, `ltolerance(`*#*`)`, `nrtolerance(`*#*`)`, `nonrtolerance`, and `from(`*init_specs*`)`; see [R] **maximize**. These options are seldom used.

The following option is available with `logistic` but is not shown in the dialog box:

`coeflegend`; see [R] **estimation options**.

Remarks and examples

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Remarks are presented under the following headings:

logistic and logit

`logistic` provides an alternative and preferred way to fit maximum-likelihood logit models, the other choice being `logit` ([R] **logit**).

First, let's dispose of some confusing terminology. We use the words logit and logistic to mean the same thing: maximum likelihood estimation. To some, one or the other of these words connotes transforming the dependent variable and using weighted least squares to fit the model, but that is not how we use either word here. Thus the `logit` and `logistic` commands produce the same results.

The `logistic` command is generally preferred to the `logit` command because `logistic` presents the estimates in terms of odds ratios rather than coefficients. To some people, this may seem disadvantageous, but you can type `logit` without arguments after `logistic` to see the underlying coefficients. You should be cautious when interpreting the odds ratio of the constant term. Usually, this odds ratio represents the baseline odds of the model when all predictor variables are set to zero. However, you must verify that a zero value for all predictor variables in the model actually makes sense before continuing with this interpretation.

Nevertheless, [R] **logit** is still worth reading because `logistic` shares the same features as `logit`, including omitting variables due to collinearity or one-way causation.

For an introduction to logistic regression, see Lemeshow and Hosmer (2005), Pagano and Gauvreau (2000, 470–487), or Pampel (2000); for a complete but nonmathematical treatment, see Kleinbaum and Klein (2010); and for a thorough discussion, see Hosmer, Lemeshow, and Sturdivant (2013). See Gould (2000) for a discussion of the interpretation of logistic regression. See Dupont (2009) or Hilbe (2009) for a discussion of logistic regression with examples using Stata. For a discussion using Stata with an emphasis on model specification, see Vittinghoff et al. (2012).

Stata has a variety of commands for performing estimation when the dependent variable is dichotomous or polytomous. See Long and Freese (2014) for a book devoted to fitting these models with Stata. Here is a list of some estimation commands that may be of interest. See `help estimation commands` for a complete list of all of Stata's estimation commands.

asclogit	[R] **asclogit**	Alternative-specific conditional logit (McFadden's choice) model
asmprobit	[R] **asmprobit**	Alternative-specific multinomial probit regression
asroprobit	[R] **asroprobit**	Alternative-specific rank-ordered probit regression
binreg	[R] **binreg**	Generalized linear models for the binomial family
biprobit	[R] **biprobit**	Bivariate probit regression
blogit	[R] **glogit**	Logit regression for grouped data
bprobit	[R] **glogit**	Probit regression for grouped data
clogit	[R] **clogit**	Conditional (fixed-effects) logistic regression
cloglog	[R] **cloglog**	Complementary log-log regression
exlogistic	[R] **exlogistic**	Exact logistic regression
glm	[R] **glm**	Generalized linear models
glogit	[R] **glogit**	Weighted least-squares logistic regression for grouped data
gprobit	[R] **glogit**	Weighted least-squares probit regression for grouped data
heckoprobit	[R] **heckoprobit**	Ordered probit model with sample selection
heckprobit	[R] **heckprobit**	Probit model with sample selection
hetprobit	[R] **hetprobit**	Heteroskedastic probit model
ivprobit	[R] **ivprobit**	Probit model with endogenous regressors
logit	[R] **logit**	Logistic regression, reporting coefficients
mecloglog	[ME] **mecloglog**	Multilevel mixed-effects complementary log-log regression
meglm	[ME] **meglm**	Multilevel mixed-effects generalized linear model
melogit	[ME] **melogit**	Multilevel mixed-effects logistic regression
meprobit	[ME] **meprobit**	Multilevel mixed-effects probit regression
mlogit	[R] **mlogit**	Multinomial (polytomous) logistic regression
mprobit	[R] **mprobit**	Multinomial probit regression
nlogit	[R] **nlogit**	Nested logit regression (RUM-consistent and nonnormalized)
ologit	[R] **ologit**	Ordered logistic regression
oprobit	[R] **oprobit**	Ordered probit regression
probit	[R] **probit**	Probit regression
rologit	[R] **rologit**	Rank-ordered logistic regression
scobit	[R] **scobit**	Skewed logistic regression
slogit	[R] **slogit**	Stereotype logistic regression
svy: *cmd*	[SVY] **svy estimation**	Survey versions of many of these commands are available; see [SVY] **svy estimation**
xtcloglog	[XT] **xtcloglog**	Random-effects and population-averaged cloglog models
xtgee	[XT] **xtgee**	GEE population-averaged generalized linear models
xtlogit	[XT] **xtlogit**	Fixed-effects, random-effects, and population-averaged logit models
xtologit	[XT] **xtologit**	Random-effects ordered logistic models
xtoprobit	[XT] **xtoprobit**	Random-effects ordered probit models
xtprobit	[XT] **xtprobit**	Random-effects and population-averaged probit models

▷ Example 1

Consider the following dataset from a study of risk factors associated with low birthweight described in Hosmer, Lemeshow, and Sturdivant (2013, 24).

```
. use http://www.stata-press.com/data/r13/lbw
(Hosmer & Lemeshow data)
. describe
Contains data from http://www.stata-press.com/data/r13/lbw.dta
  obs:           189                          Hosmer & Lemeshow data
 vars:            11                          15 Jan 2013 05:01
 size:         2,646
─────────────────────────────────────────────────────────────────────────────────
              storage   display    value
variable name   type    format     label      variable label
─────────────────────────────────────────────────────────────────────────────────
id              int     %8.0g                 identification code
low             byte    %8.0g                 birthweight<2500g
age             byte    %8.0g                 age of mother
lwt             int     %8.0g                 weight at last menstrual period
race            byte    %8.0g      race       race
smoke           byte    %9.0g      smoke      smoked during pregnancy
ptl             byte    %8.0g                 premature labor history (count)
ht              byte    %8.0g                 has history of hypertension
ui              byte    %8.0g                 presence, uterine irritability
ftv             byte    %8.0g                 number of visits to physician
                                                during 1st trimester
bwt             int     %8.0g                 birthweight (grams)
─────────────────────────────────────────────────────────────────────────────────
Sorted by:
```

We want to investigate the causes of low birthweight. Here `race` is a categorical variable indicating whether a person is white (`race` = 1), black (`race` = 2), or some other race (`race` = 3). We want indicator (dummy) variables for `race` included in the regression, so we will use factor variables.

```
. logistic low age lwt i.race smoke ptl ht ui
Logistic regression                             Number of obs     =        189
                                                LR chi2(8)        =      33.22
                                                Prob > chi2       =     0.0001
Log likelihood =   -100.724                     Pseudo R2         =     0.1416

─────────────┬────────────────────────────────────────────────────────────────
         low │ Odds Ratio   Std. Err.      z    P>|z|     [95% Conf. Interval]
─────────────┼────────────────────────────────────────────────────────────────
         age │   .9732636   .0354759    -0.74   0.457     .9061578    1.045339
         lwt │   .9849634   .0068217    -2.19   0.029     .9716834    .9984249
             │
        race │
      black  │   3.534767   1.860737     2.40   0.016     1.259736    9.918406
      other  │   2.368079   1.039949     1.96   0.050     1.001356    5.600207
             │
       smoke │   2.517698    1.00916     2.30   0.021     1.147676    5.523162
         ptl │   1.719161   .5952579     1.56   0.118     .8721455    3.388787
          ht │   6.249602   4.322408     2.65   0.008     1.611152    24.24199
          ui │     2.1351   .9808153     1.65   0.099     .8677528      5.2534
       _cons │   1.586014   1.910496     0.38   0.702     .1496092     16.8134
─────────────┴────────────────────────────────────────────────────────────────
```

The odds ratios are for a one-unit change in the variable. If we wanted the odds ratio for `age` to be in terms of 4-year intervals, we would type

```
. gen age4 = age/4
. logistic low age4 lwt i.race smoke ptl ht ui
(output omitted)
```

After `logistic`, we can type `logit` to see the model in terms of coefficients and standard errors:

```
. logit
Logistic regression                             Number of obs     =        189
                                                LR chi2(8)        =      33.22
                                                Prob > chi2       =     0.0001
Log likelihood =   -100.724                     Pseudo R2         =     0.1416

------------------------------------------------------------------------------
         low |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
        age4 |  -.1084012   .1458017    -0.74   0.457    -.3941673    .1773649
         lwt |  -.0151508   .0069259    -2.19   0.029    -.0287253   -.0015763
             |
        race |
      black  |   1.262647   .5264101     2.40   0.016     .2309024    2.294392
      other  |   .8620792   .4391532     1.96   0.050     .0013548    1.722804
             |
       smoke |   .9233448   .4008266     2.30   0.021      .137739    1.708951
         ptl |   .5418366    .346249     1.56   0.118     -.136799    1.220472
          ht |   1.832518   .6916292     2.65   0.008     .4769494    3.188086
          ui |   .7585135   .4593768     1.65   0.099    -.1418484    1.658875
       _cons |   .4612239    1.20459     0.38   0.702    -1.899729    2.822176
------------------------------------------------------------------------------
```

If we wanted to see the `logistic` output again, we would type `logistic` without arguments.

◁

▷ Example 2

We can specify the confidence interval for the odds ratios with the `level()` option, and we can do this either at estimation time or when replaying the model. For instance, to see our first model in example 1 with narrower, 90% confidence intervals, we might type

```
. logistic, level(90)
Logistic regression                             Number of obs     =        189
                                                LR chi2(8)        =      33.22
                                                Prob > chi2       =     0.0001
Log likelihood =   -100.724                     Pseudo R2         =     0.1416

------------------------------------------------------------------------------
         low | Odds Ratio   Std. Err.      z    P>|z|     [90% Conf. Interval]
-------------+----------------------------------------------------------------
        age4 |   .8972675   .1308231    -0.74   0.457     .7059409    1.140448
         lwt |   .9849634   .0068217    -2.19   0.029     .9738063    .9962483
             |
        race |
      black  |   3.534767   1.860737     2.40   0.016     1.487028    8.402379
      other  |   2.368079   1.039949     1.96   0.050     1.149971    4.876471
             |
       smoke |   2.517698    1.00916     2.30   0.021     1.302185    4.867819
         ptl |   1.719161   .5952579     1.56   0.118     .9726876    3.038505
          ht |   6.249602   4.322408     2.65   0.008     2.003487    19.49478
          ui |     2.1351   .9808153     1.65   0.099      1.00291    4.545424
       _cons |   1.586014   1.910496     0.38   0.702     .2186791    11.50288
------------------------------------------------------------------------------
```

◁

Robust estimate of variance

If you specify vce(robust), Stata reports the robust estimate of variance described in [U] 20.21 Obtaining robust variance estimates. Here is the model previously fit with the robust estimate of variance:

```
. logistic low age lwt i.race smoke ptl ht ui, vce(robust)
Logistic regression                             Number of obs     =        189
                                                Wald chi2(8)      =      29.02
                                                Prob > chi2       =     0.0003
Log pseudolikelihood =   -100.724               Pseudo R2         =     0.1416
```

low	Odds Ratio	Robust Std. Err.	z	P>|z|	[95% Conf.	Interval]
age	.9732636	.0329376	-0.80	0.423	.9108015	1.040009
lwt	.9849634	.0070209	-2.13	0.034	.9712984	.9988206
race						
black	3.534767	1.793616	2.49	0.013	1.307504	9.556051
other	2.368079	1.026563	1.99	0.047	1.012512	5.538501
smoke	2.517698	.9736417	2.39	0.017	1.179852	5.372537
ptl	1.719161	.7072902	1.32	0.188	.7675715	3.850476
ht	6.249602	4.102026	2.79	0.005	1.726445	22.6231
ui	2.1351	1.042775	1.55	0.120	.8197749	5.560858
_cons	1.586014	1.939482	0.38	0.706	.144345	17.42658

Also you can specify vce(cluster *clustvar*) and then, within cluster, relax the assumption of independence. To illustrate this, we have made some fictional additions to the low-birthweight data.

Say that these data are not a random sample of mothers but instead are a random sample of mothers from a random sample of hospitals. In fact, that may be true—we do not know the history of these data.

Hospitals specialize, and it would not be too incorrect to say that some hospitals specialize in more difficult cases. We are going to show two extremes. In one, all hospitals are alike, but we are going to estimate under the possibility that they might differ. In the other, hospitals are strikingly different. In both cases, we assume that patients are drawn from 20 hospitals.

In both examples, we will fit the same model, and we will type the same command to fit it. Below are the same data we have been using but with a new variable, hospid, that identifies from which of the 20 hospitals each patient was drawn (and which we have made up):

```
. use http://www.stata-press.com/data/r13/hospid1, clear
. logistic low age lwt i.race smoke ptl ht ui, vce(cluster hospid)
Logistic regression                               Number of obs   =        189
                                                  Wald chi2(8)    =      49.67
                                                  Prob > chi2     =     0.0000
Log pseudolikelihood =   -100.724                 Pseudo R2       =     0.1416
                                 (Std. Err. adjusted for 20 clusters in hospid)
```

low	Odds Ratio	Robust Std. Err.	z	P>|z|	[95% Conf.	Interval]
age	.9732636	.0397476	-0.66	0.507	.898396	1.05437
lwt	.9849634	.0057101	-2.61	0.009	.9738352	.9962187
race						
black	3.534767	2.013285	2.22	0.027	1.157563	10.79386
other	2.368079	.8451325	2.42	0.016	1.176562	4.766257
smoke	2.517698	.8284259	2.81	0.005	1.321062	4.79826
ptl	1.719161	.6676221	1.40	0.163	.8030814	3.680219
ht	6.249602	4.066275	2.82	0.005	1.74591	22.37086
ui	2.1351	1.093144	1.48	0.138	.7827337	5.824014
_cons	1.586014	1.661913	0.44	0.660	.2034094	12.36639

The standard errors are similar to the standard errors we have previously obtained, whether we used the robust or conventional estimators. In this example, we invented the hospital IDs randomly.

Here are the results of the estimation with the same data but with a different set of hospital IDs:

```
. use http://www.stata-press.com/data/r13/hospid2
. logistic low age lwt i.race smoke ptl ht ui, vce(cluster hospid)
Logistic regression                               Number of obs   =        189
                                                  Wald chi2(8)    =       7.19
                                                  Prob > chi2     =     0.5167
Log pseudolikelihood =   -100.724                 Pseudo R2       =     0.1416
                                 (Std. Err. adjusted for 20 clusters in hospid)
```

low	Odds Ratio	Robust Std. Err.	z	P>|z|	[95% Conf.	Interval]
age	.9732636	.0293064	-0.90	0.368	.9174862	1.032432
lwt	.9849634	.0106123	-1.41	0.160	.9643817	1.005984
race						
black	3.534767	3.120338	1.43	0.153	.6265521	19.9418
other	2.368079	1.297738	1.57	0.116	.8089594	6.932114
smoke	2.517698	1.570287	1.48	0.139	.7414969	8.548655
ptl	1.719161	.6799153	1.37	0.171	.7919045	3.732161
ht	6.249602	7.165454	1.60	0.110	.660558	59.12808
ui	2.1351	1.411977	1.15	0.251	.5841231	7.804266
_cons	1.586014	1.946253	0.38	0.707	.1431423	17.573

Note the strikingly larger standard errors. What happened? In these data, women most likely to have low-birthweight babies are sent to certain hospitals, and the decision on likeliness is based not just on age, smoking history, etc., but on other things that doctors can see but that are not recorded in our data. Thus merely because a woman is at one of the centers identifies her to be more likely to have a low-birthweight baby.

Video examples

Logistic regression, part 1: Binary predictors

Logistic regression, part 2: Continuous predictors

Logistic regression, part 3: Factor variables

Stored results

`logistic` stores the following in `e()`:

Scalars

`e(N)`	number of observations
`e(N_cds)`	number of completely determined successes
`e(N_cdf)`	number of completely determined failures
`e(k)`	number of parameters
`e(k_eq)`	number of equations in `e(b)`
`e(k_eq_model)`	number of equations in overall model test
`e(k_dv)`	number of dependent variables
`e(df_m)`	model degrees of freedom
`e(r2_p)`	pseudo-R-squared
`e(ll)`	log likelihood
`e(ll_0)`	log likelihood, constant-only model
`e(N_clust)`	number of clusters
`e(chi2)`	χ^2
`e(p)`	significance of model test
`e(rank)`	rank of `e(V)`
`e(ic)`	number of iterations
`e(rc)`	return code
`e(converged)`	`1` if converged, `0` otherwise

Macros

`e(cmd)`	`logistic`
`e(cmdline)`	command as typed
`e(depvar)`	name of dependent variable
`e(wtype)`	weight type
`e(wexp)`	weight expression
`e(title)`	title in estimation output
`e(clustvar)`	name of cluster variable
`e(offset)`	linear offset variable
`e(chi2type)`	`Wald` or `LR`; type of model χ^2 test
`e(vce)`	*vcetype* specified in `vce()`
`e(vcetype)`	title used to label Std. Err.
`e(opt)`	type of optimization
`e(which)`	`max` or `min`; whether optimizer is to perform maximization or minimization
`e(ml_method)`	type of `ml` method
`e(user)`	name of likelihood-evaluator program
`e(technique)`	maximization technique
`e(properties)`	`b V`
`e(estat_cmd)`	program used to implement `estat`
`e(predict)`	program used to implement `predict`
`e(marginsnotok)`	predictions disallowed by `margins`
`e(asbalanced)`	factor variables `fvset` as `asbalanced`
`e(asobserved)`	factor variables `fvset` as `asobserved`

Matrices

`e(b)`	coefficient vector
`e(Cns)`	constraints matrix
`e(ilog)`	iteration log (up to 20 iterations)
`e(gradient)`	gradient vector
`e(mns)`	vector of means of the independent variables
`e(rules)`	information about perfect predictors
`e(V)`	variance–covariance matrix of the estimators
`e(V_modelbased)`	model-based variance

Functions

`e(sample)`	marks estimation sample

Methods and formulas

Define $\mathbf{x}_j$ as the (row) vector of independent variables, augmented by 1, and $\mathbf{b}$ as the corresponding estimated parameter (column) vector. The logistic regression model is fit by `logit`; see [R] **logit** for details of estimation.

The odds ratio corresponding to the ith coefficient is $\psi_i = \exp(b_i)$. The standard error of the odds ratio is $s_i^{\psi} = \psi_i s_i$, where s_i is the standard error of b_i estimated by `logit`.

Define $I_j = \mathbf{x}_j \mathbf{b}$ as the predicted index of the jth observation. The predicted probability of a positive outcome is

$$p_j = \frac{\exp(I_j)}{1 + \exp(I_j)}$$

This command supports the Huber/White/sandwich estimator of the variance and its clustered version using `vce(robust)` and `vce(cluster` *clustvar*`)`, respectively. See [P] **_robust**, particularly *Maximum likelihood estimators* and *Methods and formulas*.

`logistic` also supports estimation with survey data. For details on VCEs with survey data, see [SVY] **variance estimation**.

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Also see

[R] **logistic postestimation** — Postestimation tools for logistic

[R] **brier** — Brier score decomposition

[R] **cloglog** — Complementary log-log regression

[R] **exlogistic** — Exact logistic regression

[R] **logit** — Logistic regression, reporting coefficients

[R] **roc** — Receiver operating characteristic (ROC) analysis

[MI] **estimation** — Estimation commands for use with mi estimate

[SVY] **svy estimation** — Estimation commands for survey data

[XT] **xtlogit** — Fixed-effects, random-effects, and population-averaged logit models

[U] 20 Estimation and postestimation commands