return — Return stored results

Syntax

Return results for general commands, stored in r()

```
return list [, all]
return clear
return scalar name = exp
return local name = exp
return local name ["]string["]
return matrix name [=] matname [, copy]
return add
```

Return results for estimation commands, stored in e()

```
ereturn list [, all]
ereturn clear
ereturn post [b [V [Cns]]] [weight] [, depname(string) obs(#) dof(#) esample(varname) properties(string)]
ereturn scalar name = exp
ereturn local name = exp
ereturn local name ["]string["
ereturn matrix name [=] matname [, copy]
ereturn repost [b = b] [V = V] [Cns = Cns] [weight] [, esample(varname) properties(string) rename]
```

Return results for parsing commands, stored in s()

```
sreturn list
sreturn clear
sreturn scalar name = exp
sreturn local name ["]string["
```
where b, V, and Cns are *matnames*, which is the name of an existing matrix. fweights, aweights, iweights, and pweights are allowed; see [U] 11.1.6 *weight*.

**Description**

Results of calculations are stored by many Stata commands so that they can be easily accessed and substituted into subsequent commands. This entry summarizes for programmers how to store results. If your interest is in using previously stored results, see [R] stored results.

- `return` stores results in `r()`.
- `ereturn` stores results in `e()`.
- `sreturn` stores results in `s()`.

Stata also has the values of system parameters and certain constants such as pi stored in `c()`. Because these values may be referred to but not assigned, the c-class is discussed in a different entry; see [P] creturn.

**Options**

- `all` is for use with `return list` and `ereturn list`. `all` specifies that hidden and historical stored results be listed along with the usual stored results. This option is seldom used. See Using hidden and historical stored results and Programming hidden and historical stored results in Remarks and examples for more information. These sections are written in terms of `return list`, but everything said there applies equally to `ereturn list`.

- `all` is not allowed with `sreturn list` because `s()` does not allow hidden or historical results.

- `copy` specified with `return matrix` or `ereturn matrix` indicates that the matrix is to be copied; that is, the original matrix should be left in place. The default is to “steal” or “rename” the existing matrix, which is fast and conserves memory.

- `depname(string)` is for use with `ereturn post`. It supplies the name of the dependent variable to appear in the estimation output. The name specified need not be the name of an existing variable.

- `obs(#)` is for use with `ereturn post`. It specifies the number of observations on which the estimation was performed. This number is stored in `e(N)`, and `obs()` is provided simply for convenience. Results are no different from those for `ereturn post` followed by `ereturn scalar N = #`.

- `dof(#)` is for use with `ereturn post`. It specifies the number of denominator degrees of freedom to be used with *t* and *F* statistics and so is used in calculating significance levels and confidence intervals. The number specified is stored in `e(df_r)`, and `dof()` is provided simply for convenience. Results are no different from those for `ereturn post` followed by `ereturn scalar df_r = #`.

- `esample(varname)` is for use with `ereturn post` and `ereturn repost`. It specifies the name of a 0/1 variable that is to become the `e(sample)` function. `varname` must contain 0 and 1 values only, with 1 indicating that the observation is in the estimation subsample. `ereturn post` and `ereturn repost` will be able to execute a little more quickly if `varname` is stored as a byte variable.

- `varname` is dropped from the dataset, or more correctly, it is stolen and stashed in a secret place.

- `properties(string)` specified with `ereturn post` or `ereturn repost` sets the `e(properties)` macro. By default, `e(properties)` is set to `b V` if `properties()` is not specified.
rename is for use with the \texttt{b = b} syntax of \texttt{ereturn repost}. All numeric estimation results remain unchanged, but the labels of \texttt{b} are substituted for the variable and equation names of the already posted results.

Remarks and examples

Remarks are presented under the following headings:

- Introduction
- Storing results in \texttt{r()}
- Storing results in \texttt{e()}
- Storing results in \texttt{s()}
- Recommended names for stored results
- Using hidden and historical stored results
- Programming hidden and historical stored results

Introduction

This entry summarizes information that is presented in greater detail in other parts of the Stata documentation. Most particularly, we recommend that you read \cite{U18} Programming Stata. The commands listed above are used by programmers to store results, which are accessed by others using \texttt{r()}, \texttt{e()}, and \texttt{s()}; see \cite{R}

The commands listed above may be used only in programs—see \cite{U18} Programming Stata and \cite{P} program—and then only when the program is declared explicitly as being \texttt{rclass}, \texttt{eclass}, or \texttt{sclass}:

\begin{verbatim}
program ..., rclass
  ... 
  return ...
  ... 
end

program ..., eclass
  ... 
  ereturn ...
  ... 
end

program ..., sclass
  ... 
  sreturn ...
  ... 
end
\end{verbatim}

Storing results in \texttt{r()}

- The program must be declared explicitly to be \texttt{r-class}: \texttt{program ..., rclass}.
- Distinguish between \texttt{r()} (returned results) and \texttt{return()} (results being assembled that will be returned). The program you write actually stores results in \texttt{return()}. Then when your program completes, whatever is in \texttt{return()} is copied to \texttt{r()}. Thus the program you write can consume \texttt{r()} results from other programs, and there is no conflict.
- \texttt{return clear} clears the \texttt{return()} class. This command is seldom used because \texttt{return()} starts out empty when your program begins. \texttt{return clear} is for those instances when you have started assembling results and all is going well, but given the problem at hand, you need to start all over again.
• return scalar name = exp evaluates exp and stores the result in the scalar return(name). exp must evaluate to a numeric result or missing. If your code has previously stored something in return(name), whether a scalar, matrix, or whatever else, the previous value is discarded and this result replaces it.

• return local name = exp evaluates exp and stores the result in the macro return(name). exp may evaluate to a numeric or string result. If your code has previously stored something in return(name), whether a scalar, matrix, or whatever else, the previous value is discarded and this result replaces it.

Be careful with this syntax: do not code

```
    return local name = 'mymacro'
```

because that will copy just the first 2045 characters of ‘mymacro’.
Instead, code

```
    return local name = "'mymacro'"
```

• return local name string copies string to macro return(name). If your code has previously stored something in return(name), whether a scalar, matrix, or whatever else, the previous value is discarded and this result replaces it.

If you do not enclose string in double quotes, multiple blanks in string are compressed into single blanks.

• return matrix name matname destructively copies matname into matrix return(name), meaning that matname is erased (matname is renamed return(name)). If your code has previously stored something in return(name), whether a scalar, matrix, or whatever else, the previous value is discarded and this result replaces it.

• return add copies everything new in r() into return(). Say that your program performed a summarize. return add lets you add everything just returned by summarize to the to-be-returned results of your program. If your program had already set return(N), summarize’s r(N) would not replace the previously set result. The remaining r() results set by summarize would be copied.

### Storing results in e(

For detailed guidance on storing in e(), see [P] ereturn. What follows is a summary.

• The program must be declared explicitly to be e-class: program ..., eclass.

• The e-class is cleared whenever an ereturn post is executed. The e-class is a static, single-level class, meaning that results are posted to the class the instant that they are stored.

• ereturn clear clears e(). This is a rarely used command.

• ereturn post is how you must begin storing results in e(). Because ereturn post clears e(), anything stored in e() prior to the ereturn post is lost.

ereturn post stores matrix (vector, really) e(b), matrices e(V) and e(Cns), weight-related macros e(wtype) and e(wexp), and function e(sample). The most common syntax is

```
    ereturn post 'b' 'V', esample('touse') ...
```

where ‘b’ is a row vector containing the parameter estimates, ‘V’ is a symmetric matrix containing the variance estimates, and ‘touse’ is a 0/1 variable recording 1 in observations that appear in the estimation subsample.
The result of this command will be that ‘b’, ‘V’, and ‘touse’ all disappear. In fact, e(returns) examines what you specify and, if it is satisfied with them, renames them e(b), e(V), and e(sample).

For more advanced usage that also posts constraint and weight information, see [P] e(returns).

In terms of e(returns)’s other options,

a. We recommend that you specify depname(string) if there is one dependent variable name that you want to appear on the output. Whether you specify depname() or not, remember later to define macro e(depvar) to contain the names of the dependent variables.

b. Specify obs(#), or remember later to define scalar e(N) to contain the number of observations.

c. Few models require specifying dof(#), or, if that is not done, remembering to later define scalar e(df_r). This all has to do with substituting t and F statistics on the basis of # (denominator) degrees of freedom for asymptotic z and \( \chi^2 \) statistics in the estimation output.

- **e(returns) scalar name = exp** evaluates exp and stores the result in the scalar e(name). exp must evaluate to a numeric result or missing. If your code has previously stored something in e(name), whether that be a scalar, matrix, or whatever else, the previous value is discarded and this result replaces it.

- **e(returns) local name = exp** evaluates exp and stores the result in the macro e(name). exp may evaluate to a numeric or string result. If your code has previously stored something in e(name), whether that be a scalar, matrix, or whatever else, the previous value is discarded and this result replaces it.

Be careful with this syntax: do not code

```
    e(returns) local name = 'mymacro'
```

because that will copy just the first 2045 characters of ‘mymacro’. Instead, code

```
    e(returns) local name = "'mymacro'
```

- **e(returns) local name string** copies string to macro e(name). If your code has previously stored something in e(name), whether a scalar, matrix, or whatever else, the previous value is discarded and this result replaces it.

If you do not enclose string in double quotes, multiple blanks in string are compressed into single blanks.

- **e(returns) matrix name = matname** destructively copies matname into matrix e(name), meaning that matname is erased. At least, that is what happens if you do not specify the copy option. What actually occurs is that matname is renamed e(name). If your code has previously stored something in e(name), whether a scalar, matrix, or whatever else, the previous value is discarded and this result replaces it, with two exceptions:

  e(returns) matrix cannot be used to store in e(b) or e(V). The only way to post matrices to these special names is to use e(returns) post and e(returns) repost so that various tests can be run on them before they are made official. Other Stata commands use e(b) and e(V) and expect to see a valid estimation result. If e(b) is 1 × k, they expect e(V) to be k × k. They expect that the names of rows and columns will be the same so that the ith column of e(b) corresponds to the ith row and column of e(V). They expect e(V) to be symmetric. They expect e(V) to have positive or zero elements along its diagonal, and so on. e(returns) post and e(returns) repost check these assumptions.
- `ereturn repost` allows changing `e(b)`, `e(V)`, `e(Cns)`, `e(wtype)`, `e(wexp)`, `e(properties)`, and `e(sample)` without clearing the estimation results and starting all over again. As with `ereturn post`, specified matrices and variables disappear after reposting because they are renamed `e(b)`, `e(V)`, `e(Cns)`, or `e(sample)` as appropriate.

- Programmers posting estimation results should remember to store
  a. Macro `e(cmd)`, containing the name of the estimation command. Make this the last thing you store in `e()`.
  b. Macro `e(cmdline)`, containing the command the user typed.
  c. Macro `e(depvar)`, containing the names of the dependent variables.
  d. Scalar `e(N)`, containing the number of observations.
  e. Scalar `e(df_m)`, containing the model degrees of freedom.
  f. Scalar `e(df_r)`, containing the denominator degrees of freedom if estimates are nonasymptotic; otherwise, do not define this result.
  g. Scalar `e(ll)`, containing the log-likelihood value, if relevant.
  h. Scalar `e(ll_0)`, containing the log-likelihood value for the constant-only model, if relevant.
  i. Scalar `e(chi2)`, containing the $\chi^2$ test of the model against the constant-only model, if relevant.
  j. Macro `e(chi2type)`, containing LR, Wald, or other, depending on how `e(chi2)` was obtained.
  k. Scalar `e(r2)`, containing the value of the $R^2$ if it is calculated.
  l. Scalar `e(r2_p)`, containing the value of the pseudo-$R^2$ if it is calculated.
  m. Macro `e(vce)`, containing the name of the `vcetype` that was specified in the `vce()` option; see [R] vce_option.
  n. Macro `e(vcetype)`, containing the text to appear above standard errors in estimation output, typically Robust, or it is undefined.
  o. Macro `e(clustvar)`, containing the name of the cluster variable, if any.
  p. Scalar `e(N_clust)`, containing the number of clusters.
  q. Scalar `e(rank)`, containing the rank of `e(V)`.
  r. Macro `e(predict)`, containing the name of the command that `predict` is to use; if this is blank, `predict` uses the default `_predict`.
  s. Macro `e(estat_cmd)`, containing the name of an `estat` handler program if you wish to customize the behavior of `estat`.
  t. Macro `e(properties)`, containing properties of the estimation command, typically `b V`, indicating that the command produces a legitimate coefficient vector and VCE matrix.

### Storing results in s()

- The program must be declared explicitly to be s-class: `program ... , sclass`.
- The s-class is not cleared automatically. It is a static, single-level class. Results are posted to `s()` the instant they are stored.
- `sreturn clear` clears `s()`. We recommend that you use this command near the top of s-class routines. `sreturn clear` may be used in non–s-class programs, too.
• The s-class provides macros only and is intended for returning results of subroutines that parse input. At the parsing step, it is important that the r-class not be changed or cleared because some of what still awaits being parsed might refer to \( r() \), and the user expects those results to substitute according to what was in \( r() \) when he or she typed the command.

• `sreturn local name = exp` evaluates \( exp \) and stores the result in the macro \( s(name) \). \( exp \) may evaluate to a numeric or string result. If your code has previously stored something else in \( s(name) \), the previous value is discarded and this result replaces it.

Be careful with this syntax: do not code

```
sreturn local name = ‘mymacro’
```

because that will copy just the first 2045 characters of ‘mymacro’. Instead, code

```
sreturn local name = “’mymacro’”
```

• `sreturn local name string` copies `string` to macro \( s(name) \). If your code has previously stored something else in \( s(name) \), the previous value is discarded and this result replaces it.

If you do not enclose `string` in double quotes, multiple blanks in `string` are compressed into single blanks.

Recommended names for stored results

Users will appreciate it if you use predictable names for your stored results. We use these rules:

• Mathematical and statistical concepts such as number of observations and degrees of freedom are given short mathematical-style names. Subscripting is indicated with ‘\(_\)’. Names are to proceed from the general to the specific. If \( N \) means number of observations, \( N_{-1} \) might be the number of observations in the first group.

Suffixes are to be avoided where possible. For instance, a \( \chi^2 \) statistic would be recorded in a variable starting with `chi2`. If, in the context of the command, a statement about “the \( \chi^2 \) statistic” would be understood as referring to this statistic, then the name would be `chi2`. If it required further modification, such as \( \chi^2 \) for the comparison test, then the name might be `chi2_c`.

Common prefixes are

- `N` number of observations
- `df` degrees of freedom
- `k` count of parameters
- `n` generic count
- `lb` and `ub` lower and upper bound of confidence interval
- `chi2` \( \chi^2 \) statistic
- `t` \( t \) statistic
- `F` \( F \) statistic
- `p` significance
- `p` and `pr` probability
- `ll` log likelihood
- `D` deviance
- `r2` \( R^2 \)

• Programming concepts, such as lists of variable names, are given English-style names. Names should proceed from the specific to the general. The name of the dependent variable is `depvar`, not `vardep`. 
Some examples are

- **depvar**: dependent variable names
- **eqnames**: equation names
- **model**: name of model fit
- **xvar**: x variable
- **title**: title used

- Popular usage takes precedence over the rules. For example:
  a. **mss** is model sum of squares, even though, per the first rule of this section, it ought to be **ss_m**.
  b. **mean** is used as the prefix to record means.
  c. **Var** is used as the prefix to mean variance.
  d. The returned results from most Stata commands follow this rule.

### Using hidden and historical stored results

Most results stored in `r()` and `e()` are visible—type `return list`. Sometimes, other stored results exist, too. For instance, consider the Stata command `summarize`. Let’s pretend that in addition to everything that `summarize` stores in `r()`—you know about `r(N)`, `r(mean)`, `r(sd)`, etc.—`summarize` also stores `r(secret)` and `r(sigma)`.

- `summarize` does not do this, but pretend that it did. If `summarize` stored `r(secret)` as hidden and `r(sigma)` as historical, you would not know they existed from the output of `return list` unless you typed `return list, all`. If you typed that command, you would discover `r(secret)` and `r(sigma)`, and you might learn from the output that `r(secret)` was hidden whereas `r(sigma)` was historical. The output is trying to tell you 1) the two stored results exist, 2) you may use them just as you use any other stored result, and 3) the reason why the two stored results were not listed by default.

There are two reasons why `summarize` might not store results so that you can see them when you type `return list`.

- The first reason is that `summarize` is designed to work tightly with some other Stata subroutine and is using `r()` to pass complicated information. The information that is stored is so arcane that you would not want to read documentation about it. Stata puts such stored results into the hidden category where you will not see them by default. If you type `return list, all` and find hidden stored results, we recommend that you do not use their contents in your own do- and ado-files. Because hidden stored results are not documented, their names, contents, and even their existence could change in future releases.

- The other reason `summarize` might omit a stored result from `return list` concerns backward compatibility. Assume that for Stata 4, `summarize` stored the standard deviation in `r(sigma)` instead of `r(sd)`. Assume that the editors at StataCorp decided later that `r(sd)` would be a better name. The programmers at StataCorp could not simply change the name from `r(sigma)` to `r(sd)`, because users might have already written do- or ado-files before the change. Changing the name could break old do- and ado-files, and it is a hallmark of Stata that your code will continue to work regardless of how long ago users wrote it. Thus the programmers at StataCorp could choose to store the standard deviation in both `r(sigma)` and `r(sd)` in all cases, or they could store the standard deviation in `r(sigma)` and store it in `r(sigma)` only when the old do- or ado-file explicitly included a version 4 or earlier statement. Either way, `r(sigma)` is of no interest to modern Stata users, and so the programmers mark `r(sigma)` as historical. Now when you type `return list`, you will not see `r(sigma)` mentioned; and when you type `return list, all`, you will see `r(sigma)` listed, and you are told that it was not mentioned earlier because it is marked as historical.
Typing `return list, all` can be useful when you are debugging or adding new features to an old program and want to see the historical stored results to better understand your old program.

What was just said about `r()` and `return list` applies equally to `e()` and `ereturn list`, and it applies equally to user-written additions to Stata and to official Stata commands. That’s the story of all.

Programmers wishing to exploit the hidden and historical markings in their own programs should see the next section.

**Programming hidden and historical stored results**

You can mark stored results as hidden or historical by specifying the optional `hcat` argument with the appropriate `return` or `ereturn` command:

```
return [hcat] scalar name = exp
return [hcat] local name = exp
return [hcat] local name "string"
return [hcat] matrix name [=] matname[, copy]

ereturn [hcat] scalar name = exp
ereturn [hcat] local name = exp
ereturn [hcat] local name "string"
ereturn [hcat] matrix name [=] matname[, copy]
```

`hcat` specifies the hiddenness of the result and may be

- `visible`
- `hidden`
- `historical[ (relno) ]`

where `relno` is `# # [ . # [ # ] ]` such as 2, 10, 10., 10.1, or 10.12. `visible` is the default when `hcat` is not specified.

Thus if you are writing an r-class command and wish to store `r(private)` as a hidden scalar, you can code

```
return hidden scalar private = ...
```

If you wish to store `r(lastvar)` as a hidden local, you can code

```
return hidden local lastvar "...
```

If you wanted `r(lastvar)` to be historical rather than hidden, you would code

```
return historical local lastvar "...
```

If you wanted `r(lastvar)` to be historical as of Stata 13, meaning that `r(lastvar)` was current up to but not including Stata 13, you would code

```
return historical(12) local lastvar "...
```

If you wish to create `r(X)` as a hidden matrix, you can code

```
return hidden matrix X = ...
```
All the above examples could be performed using `ereturn` instead of `return`. They could not be performed using `sreturn` because `s()` does not allow hidden or historical results.


Also see

[P] `creturn` — Return c-class values
[P] `ereturn` — Post the estimation results
[P] `estimates` — Manage estimation results
[P] `putexcel` — Export results to an Excel file
[P] `return` — Preserve stored results
[R] `stored results` — Stored results
[U] 18 Programming Stata
[U] 18.10 Storing results