

**varsoc** — Obtain lag-order selection statistics for VARs and VECMs

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## Syntax

### Preestimation syntax

```
varsoc depvarlist [if] [in] [, preestimation_options]
```

### Postestimation syntax

```
varsoc [, estimates(estname)]
```

<i>preestimation_options</i>	Description
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#### Main

<u>maxlag</u> (#)	set maximum lag order to #; default is maxlag(4)
<u>exog</u> ( <i>varlist</i> )	use <i>varlist</i> as exogenous variables
<u>constraints</u> ( <i>constraints</i> )	apply constraints to exogenous variables
<u>noconstant</u>	suppress constant term
<u>lutstats</u>	use Lütkepohl's version of information criteria
<u>level</u> (#)	set confidence level; default is level(95)
<u>separator</u> (#)	draw separator line after every # rows

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You must `tsset` your data before using `varsoc`; see [TS] [tsset](#).

`by` is allowed with the preestimation version of `varsoc`; see [U] [11.1.10 Prefix commands](#).

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## Description

`varsoc` reports the final prediction error (FPE), Akaike's information criterion (AIC), Schwarz's Bayesian information criterion (SBIC), and the Hannan and Quinn information criterion (HQIC) lag-order selection statistics for a series of vector autoregressions of order 1, . . . , `maxlag()`. A sequence of likelihood-ratio test statistics for all the full VARs of order less than or equal to the highest lag order is also reported. In the postestimation version, the maximum lag and estimation options are based on the model just fit or the model specified in `estimates(estname)`.

The preestimation version of `varsoc` can also be used to select the lag order for a vector error-correction model (VECM). As shown by [Nielsen \(2001\)](#), the lag-order selection statistics discussed here can be used in the presence of I(1) variables.

## Preestimation options

Main

`maxlag(#)` specifies the maximum lag order for which the statistics are to be obtained.

`exog(varlist)` specifies exogenous variables to include in the VARs fit by `varsoc`.

`constraints(constraints)` specifies a list of constraints on the exogenous variables to be applied.

Do not specify constraints on the lags of the endogenous variables because specifying one would mean that at least one of the VAR models considered by `varsoc` will not contain the lag specified in the constraint. Use `var` directly to obtain selection-order criteria with constraints on lags of the endogenous variables.

`noconstant` suppresses the constant terms from the model. By default, constant terms are included.

`lutstats` specifies that the [Lütkepohl \(2005\)](#) versions of the information criteria be reported. See [Methods and formulas](#) for a discussion of these statistics.

`level(#)` specifies the confidence level, as a percentage, that is used to identify the first likelihood-ratio test that rejects the null hypothesis that the additional parameters from adding a lag are jointly zero. The default is `level(95)` or as set by `set level`; see [\[U\] 20.7 Specifying the width of confidence intervals](#).

`separator(#)` specifies how often separator lines should be drawn between rows. By default, separator lines do not appear. For example, `separator(1)` would draw a line between each row, `separator(2)` between every other row, and so on.

## Postestimation option

`estimates(estname)` specifies the name of a previously stored set of `var` or `svar` estimates.

When no `depvarlist` is specified, `varsoc` uses the *postestimation syntax* and uses the currently active estimation results or the results specified in `estimates(estname)`. See [\[R\] estimates](#) for information on manipulating estimation results.

## Remarks and examples

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

Many selection-order statistics have been developed to assist researchers in fitting a VAR of the correct order. Several of these selection-order statistics appear in the [\[TS\] var](#) output. The `varsoc` command computes these statistics over a range of lags  $p$  while maintaining a common sample and option specification.

`varsoc` can be used as a preestimation or a postestimation command. When it is used as a preestimation command, a *depvarlist* is required, and the default maximum lag is 4. When it is used as a postestimation command, `varsoc` uses the model specification stored in *estname* or the previously fitted model.

`varsoc` computes four information criteria as well as a sequence of likelihood ratio (LR) tests. The information criteria include the FPE, AIC, the HQIC, and SBIC.

For a given lag  $p$ , the LR test compares a VAR with  $p$  lags with one with  $p - 1$  lags. The null hypothesis is that all the coefficients on the  $p$ th lags of the endogenous variables are zero. To use this sequence of LR tests to select a lag order, we start by looking at the results of the test for the model with the most lags, which is at the bottom of the table. Proceeding up the table, the first test that rejects the null hypothesis is the lag order selected by this process. See [Lütkepohl \(2005, 143–144\)](#) for more information on this procedure. An ‘\*’ appears next to the LR statistic indicating the optimal lag.

For the remaining statistics, the lag with the smallest value is the order selected by that criterion. An ‘\*’ indicates the optimal lag. Strictly speaking, the FPE is not an information criterion, though we include it in this discussion because, as with an information criterion, we select the lag length corresponding to the lowest value; and, naturally, we want to minimize the prediction error. The AIC measures the discrepancy between the given model and the true model, which, of course, we want to minimize. [Amemiya \(1985\)](#) provides an intuitive discussion of the arguments in [Akaike \(1973\)](#). The SBIC and the HQIC can be interpreted similarly to the AIC, though the SBIC and the HQIC have a theoretical advantage over the AIC and the FPE. As [Lütkepohl \(2005, 148–152\)](#) demonstrates, choosing  $p$  to minimize the SBIC or the HQIC provides consistent estimates of the true lag order,  $p$ . In contrast, minimizing the AIC or the FPE will overestimate the true lag order with positive probability, even with an infinite sample size.

## ► Example 1: Preestimation

Here we use `varsoc` as a preestimation command.

```
. use http://www.stata-press.com/data/r13/lutkepohl2
(Quarterly SA West German macro data, Bil DM, from Lutkepohl 1993 Table E.1)
. varsoc dln_inv dln_inc dln_consump if qtr<=tq(1978q4), lutstats
Selection-order criteria (lutstats)
Sample: 1961q2 - 1978q4                Number of obs   =       71
```

lag	LL	LR	df	p	FPE	AIC	HQIC	SBIC
0	564.784				2.7e-11	-24.423	-24.423*	-24.423*
1	576.409	23.249	9	0.006	2.5e-11	-24.497	-24.3829	-24.2102
2	588.859	24.901*	9	0.003	2.3e-11*	-24.5942*	-24.3661	-24.0205
3	591.237	4.7566	9	0.855	2.7e-11	-24.4076	-24.0655	-23.5472
4	598.457	14.438	9	0.108	2.9e-11	-24.3575	-23.9012	-23.2102

```
Endogenous:  dln_inv dln_inc dln_consump
Exogenous:   _cons
```

The sample used begins in 1961q2 because all the VARs are fit to the sample defined by any `if` or `in` conditions and the available data for the maximum lag specified. The default maximum number of lags is four. Because we specified the `lutstats` option, the table contains the [Lütkepohl \(2005\)](#) versions of the information criteria, which differ from the standard definitions in that they drop the constant term from the log likelihood. In this example, the likelihood-ratio tests selected a model with two lags. AIC and FPE have also both chosen a model with two lags, whereas SBIC and HQIC have both selected a model with zero lags.

## ▷ Example 2: Postestimation

`varsoc` works as a postestimation command when no dependent variables are specified.

```
. var dln_inc dln_consump if qtr<=tq(1978q4), lutstats exog(l.dln_inv)
(output omitted)
. varsoc
Selection-order criteria (lutstats)
Sample: 1960q4 - 1978q4                Number of obs   =       73
```

lag	LL	LR	df	p	FPE	AIC	HQIC	SBIC
0	460.646				1.3e-08	-18.2962	-18.2962	-18.2962*
1	467.606	13.919	4	0.008	1.2e-08	-18.3773	-18.3273	-18.2518
2	477.087	18.962*	4	0.001	1.0e-08*	-18.5275*	-18.4274*	-18.2764

```
Endogenous:  dln_inc dln_consump
Exogenous:   L.dln_inv _cons
```

Because we included one lag of `dln_inv` in our original model, `varsoc` did likewise with each model it fit.

◀

Based on the work of [Tsay \(1984\)](#), [Paulsen \(1984\)](#), and [Nielsen \(2001\)](#), these lag-order selection criteria can be used to determine the lag length of the VAR underlying a VECM. See [\[TS\] vec intro](#) for an example in which we use `varsoc` to choose the lag order for a VECM.

**Stored results**

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

## Scalars

<code>r(N)</code>	number of observations	<code>r(mlag)</code>	maximum lag order
<code>r(tmax)</code>	last time period in sample	<code>r(N_gaps)</code>	the number of gaps in the sample
<code>r(tmin)</code>	first time period in sample		

## Macros

<code>r(endog)</code>	names of endogenous variables	<code>r(exog)</code>	names of exogenous variables
<code>r(lutstats)</code>	lutstats, if specified	<code>r(rmlutstats)</code>	rmlutstats, if specified
<code>r(cns#)</code>	the #th constraint		

## Matrices

<code>r(stats)</code>	LL, LR, FPE, AIC, HQIC, SBIC, and $p$ -values
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**Methods and formulas**

As shown by [Hamilton \(1994, 295–296\)](#), the log likelihood for a VAR( $p$ ) is

$$LL = \left(\frac{T}{2}\right) \left\{ \ln(|\hat{\Sigma}^{-1}|) - K \ln(2\pi) - K \right\}$$

where  $T$  is the number of observations,  $K$  is the number of equations, and  $\widehat{\Sigma}$  is the maximum likelihood estimate of  $E[\mathbf{u}_t \mathbf{u}_t']$ , where  $\mathbf{u}_t$  is the  $K \times 1$  vector of disturbances. Because

$$\ln(|\widehat{\Sigma}^{-1}|) = -\ln(|\widehat{\Sigma}|)$$

the log likelihood can be rewritten as

$$\text{LL} = -\left(\frac{T}{2}\right) \left\{ \ln(|\widehat{\Sigma}|) + K \ln(2\pi) + K \right\}$$

Letting  $\text{LL}(j)$  be the value of the log likelihood with  $j$  lags yields the LR statistic for lag order  $j$  as

$$\text{LR}(j) = 2 \{ \text{LL}(j) - \text{LL}(j-1) \}$$

### Model-order statistics

The formula for the FPE given in Lütkepohl (2005, 147) is

$$\text{FPE} = |\Sigma_u| \left( \frac{T + Kp + 1}{T - Kp - 1} \right)^K$$

This formula, however, assumes that there is a constant in the model and that none of the variables are dropped because of collinearity. To deal with these problems, the FPE is implemented as

$$\text{FPE} = |\Sigma_u| \left( \frac{T + \bar{m}}{T - \bar{m}} \right)^K$$

where  $\bar{m}$  is the average number of parameters over the  $K$  equations. This implementation accounts for variables dropped because of collinearity.

By default, the AIC, SBIC, and HQIC are computed according to their standard definitions, which include the constant term from the log likelihood. That is,

$$\begin{aligned} \text{AIC} &= -2 \left( \frac{\text{LL}}{T} \right) + \frac{2t_p}{T} \\ \text{SBIC} &= -2 \left( \frac{\text{LL}}{T} \right) + \frac{\ln(T)}{T} t_p \\ \text{HQIC} &= -2 \left( \frac{\text{LL}}{T} \right) + \frac{2 \ln\{\ln(T)\}}{T} t_p \end{aligned}$$

where  $t_p$  is the total number of parameters in the model and LL is the log likelihood.

## Lutstats

Lütkepohl (2005) advocates dropping the constant term from the log likelihood because it does not affect inference. The Lütkepohl versions of the information criteria are

$$\begin{aligned} \text{AIC} &= \ln(|\Sigma_u|) + \frac{2pK^2}{T} \\ \text{SBIC} &= \ln(|\Sigma_u|) + \frac{\ln(T)}{T} pK^2 \\ \text{HQIC} &= \ln(|\Sigma_u|) + \frac{2\ln\{\ln(T)\}}{T} pK^2 \end{aligned}$$

## References

- Akaike, H. 1973. Information theory and an extension of the maximum likelihood principle. In *Second International Symposium on Information Theory*, ed. B. N. Petrov and F. Csaki, 267–281. Budapest: Akailseoniai–Kiudo.
- Amemiya, T. 1985. *Advanced Econometrics*. Cambridge, MA: Harvard University Press.
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- Tsay, R. S. 1984. Order selection in nonstationary autoregressive models. *Annals of Statistics* 12: 1425–1433.

## Also see

- [TS] **var** — Vector autoregressive models
- [TS] **var svar** — Structural vector autoregressive models
- [TS] **varbasic** — Fit a simple VAR and graph IRFs or FEVDs
- [TS] **vec** — Vector error-correction models
- [TS] **var intro** — Introduction to vector autoregressive models
- [TS] **vec intro** — Introduction to vector error-correction models