EViews 10 Add-in: IV MLE SVAR Estimation Utility

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EViews 10 added new features to its VAR/SVAR object that allowed users to impose a richer range of restrictions to identify the system, including parametric restrictions on the descriptive VAR and combined short-and long-run restrictions. EViews estimates the unknown parameters of the SVAR using the maximum likelihood estimator and non-linear optimization techniques. Convergence is typically fast provided the starting values for the unknown parameters are reasonable. In practice, however, it is difficult to set useful starting values, resulting in convergence issues that are difficult to resolve.

As explained in Ouliaris, Pagan and Restrepo (2016), henceforth OPR, for exactly identified SVARs, where the number of moment restrictions available for estimation is identical to the number of parameters, the Maximum Likelihood estimator (MLE) is identical to an instrumental variables (IV) estimator. The IV estimator is used in OPR to handle most of the combinations of restrictions that are now supported explicitly by the SVAR object in EViews 10.

IV estimation has the advantage of requiring only the use of the linear two stage least squares estimator, thereby avoiding numerical optimization issues. As such, it provides a natural mechanism for finding starting values for the MLE estimator.

Given the restrictions implied in the A, B, S, and F matrices[1] of the SVAR, and any zero restrictions on the *lagged variables of the descriptive* VAR, this add-in builds the corresponding IV regression objects required to estimate the SVAR. It then uses the IV estimates to initialize the MLE/SVAR estimator. Because the starting values are equivalent to the ML estimator, convergence is quick and typically without any numerical issues.

This add-in is especially useful for procedures that depend on repeated invocations of the MLE routine, e.g., bootstrap procedures to estimate the standard errors or Monte-Carlo experiments.

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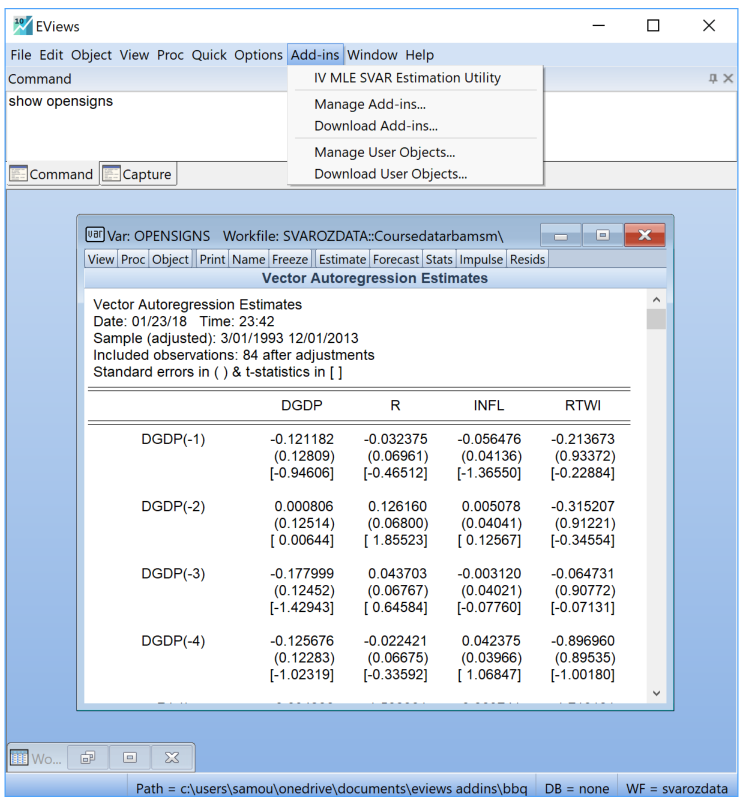
[1]In EViews notation, the basic model is $Au = Be$, where u represents the residuals of the descriptive VAR and e denotes the structural errors, $S = A^{-1}B$ is a square matrx showing the short-run restrictions, while F shows the long-run restrictions.

Using the IV/MLE Add-in

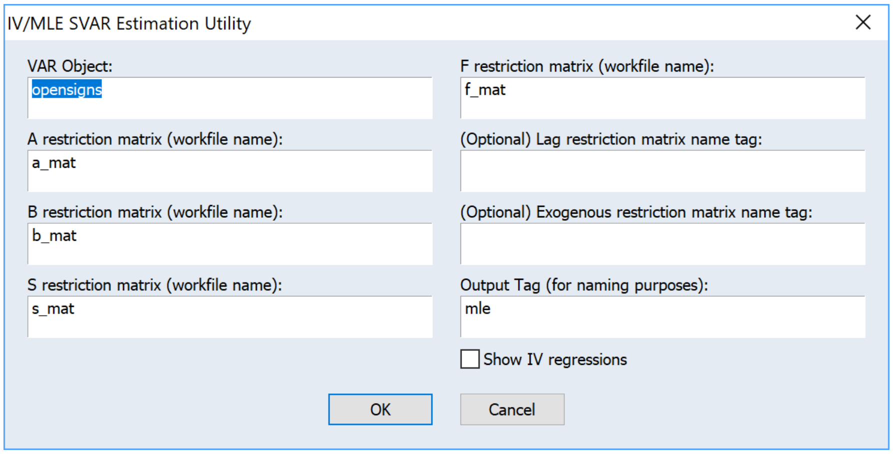
Once installed, the add-in can be invoked from the "Add-ins" menu after the VAR has been estimated. This is shown in Figure 1.

For the purpose of explaining how the add-in works, consider a 4 variable VAR with 2 lags. The variables in the VAR are the de-meaned change in the real GDP (called DGDP in the data set), the nominal interest rate (R), the inflation rate (INFL), and the real trade-weighted index for the Australian dollar (RTWI). The objective is to estimate a VAR with short-run and long-run restrictions, allowing for any zero restrictions on the descriptive VAR. Both the data and the VAR object can be found in the workfile called *svarozdata.wf1* (see "opensigns").

Clicking on the "Add-ins" menu reveals a menu entry that invokes the "IV MLE SVAR Estimation Utilty" (Figure 1).



Clicking on this menu item invokes the add-in and produces the following screen:



for which the user is required to provide entries that specify the following four matrices A, B, S, F that describe the SVAR and any restrictions on the lagged variables in the descriptive VAR.

- **VAR Object:** the name of the VAR object to use in the active pagefile (in this case "**opensigns**")
- The **A restriction matrix (workfile name):** the name of a square matrix in the active pagefile detailing the required restrictions on the A matrix of the SVAR (i.e., on the contemporaneous coefficients). In this example, the matrix's name is **A_MAT** and has the form: $\begin{bmatrix} 1.0 & NA & NA & NA \\ NA & 1.0 & NA & .036 \\ NA & NA & 1.0 & NA \\ NA & NA & NA & 1.0 \end{bmatrix}$. Note that there are two sets of restrictions imposed on A. First a normalization that sets $A(i,i) = 1$ and second the contemporaneous coefficient between the nominal interest rate and the real trade weighted dollar index ($A(2,4)$)), which is set to 0.036. The remaining contemporaneous parameters in the system are freely estimated.
- The **B restriction matrix (workfile name)**: the name of a square matrix showing the required restrictions on the variance-covariance matrix of the structural errors. This matrix is typically a diagonal matrix with NA terms that represent the unknown variances of the structural errors. In this example, the name of the matrix is **B_MAT** and it has the form: $\begin{bmatrix} NA & 0 & 0 & 0 \\ 0 & NA & 0 & 0 \\ 0 & 0 & NA & 0 \\ 0 & 0 & 0 & NA \end{bmatrix}$, i.e., the structural shocks are uncorrelated.

With the assumption regarding B above and A having equations normalized via the unit entries on the diagonal, OPR (Section 4.4.2) show that to identify the parameters of the SVAR requires 6 restrictions. One is already present in A, i.e. $A(2,4) = 0.036$, so five more restrictions are needed, and these will be described in the S and F matrices.

- The **S restriction matrix (workfile name)** is the name of a square matrix stating the "short-run" restrictions to be imposed on the contemporaneous impulse response functions. In this example, the name of the matrix in the workfile is **S_MAT** and it has the form: $\begin{bmatrix} NA & 0 & 0 & NA \\ NA & NA & NA & NA \\ NA & NA & NA & NA \\ NA & NA & NA & NA \end{bmatrix}$, imposing 2 zero restrictions. These imply that the growth in demeaned real GDP is contemporaneously invariant to both inflation and interest rate shocks. Because $S = A^{-1}B$, prescribing S in this way effectively imposes restrictions upon A, and one must be careful to ensure that these do not conflict with any of the explicit restrictions placed on A. For example, if we set $A = \begin{bmatrix} 1.0 & 0 & 0 & 0 \\ NA & 1.0 & NA & .036 \\ NA & NA & 1.0 & NA \\ NA & NA & NA & 1.0 \end{bmatrix}$, this implies that $S = \begin{bmatrix} NA & 0 & 0 & 0 \\ NA & NA & NA & NA \\ NA & NA & NA & NA \\ NA & NA & NA & NA \end{bmatrix}$. However, the first row of S does not represent any *new* restrictions, and so we would need to use the default $S = \begin{bmatrix} NA & NA & NA & NA \\ NA & NA & NA & NA \\ NA & NA & NA & NA \\ NA & NA & NA & NA \end{bmatrix}$. Of course after estimation EViews will show that $S = \begin{bmatrix} NA & 0 & 0 & 0 \\ NA & NA & NA & NA \\ NA & NA & NA & NA \\ NA & NA & NA & NA \end{bmatrix}$.

- The **F restriction matrix (workfile name):** the name of a square matrix showing the "long-run" restrictions to be imposed on the structural VAR, i.e., the impact of shocks upon the levels of the $I(1)$ variables in the system. In this example, the name of the matrix is **F_MAT** and it has the form: $\begin{bmatrix} NA & 0 & 0 & 0 \\ NA & NA & NA & NA \\ NA & NA & NA & NA \\ NA & NA & NA & NA \end{bmatrix}$. The zero entries impose the requirement that the accumulated response of the log of real GDP to the three transitory shocks is zero in the long run, i.e. only the first shock has a long-run impact upon the $I(1)$ variable, which is the log level of GDP.

- (Optional) A **name tag** (string) for the workfile matrices that determine whether or not the lagged coefficients of the structural VAR will be constrained to zero. For example, if the name tag is "_lagged" and the lag order of the VAR is N, the add-in will expect matrices named "_lagged1 _lagged2 _lagged3 ... _laggedN" in the current pagefile. Setting _lagged2(i,j) = 0 constrains the second lag of the j^{th} variable in the i^{th} equation to be zero, i.e., in terms of the EViews10 screen when $i = 1$, $j = 3$ this would imply $L2(1, 3) = 0$. It will not be constrained if _lagged2(i,j) = NA. Note that if the VAR object already has constraints (EViews 10 and above), these will be overridden by the settings in "_lagged1 _lagged2 _lagged3 ... _laggedN". Leave this field empty to use the embedded constraints in the VAR (if any).

- (Optional) A **name tag** (string) for the workfile matrices that determine whether or not the coefficients of the exogenous variables of the VAR will be constrained to zero. For example, if the tag is "_exog", and there are N exogenous variables, then the add-in will expect the matrices "_exog1 _exog2 _exog3 ... _exogN" in the current pagefile. By default, the add-in will always include the constant in position 1 (irrespective of the position the constant takes in the exogenous variable list). Hence, _exog1(i) = 0 constrains the constant term of the i^{th} equation to be zero, while _exog1(i) = NA removes the same constraint. Note that if the VAR object has existing constraints on the exogenous variables, these will be overridden by the constraints specified in "_exog1 _exog2 _exog3 ... _exogN". Leave this field empty to use the embedded constraints in the VAR (if any).

- (Optional) An **Output Tag (for naming purposes):** this is a string that will be appended to all the regression objects created by the add-in. This is useful for cases where the user wishes to compare the estimated parameters across different settings of the restriction space. The default output tag is "mle".

- (Optional) The **Show IV regressions** check box: when checked, the add-in will display the IV regressions estimated by the add-in. The default is not to display these regressions.

Clicking on the **OK** button starts the estimation procedure. The descriptive VAR is re-estimated and its residuals are saved in the workfile (see **"var_mle_res_eqn_#"** , where # [1,2,3, ...] indicates the equation number).[2] Given the current settings of the A, B, S and F matrices, the implied IV regressions are constructed and estimated (see **"iv_mle_eqn_#"**) and their residuals may be used as instruments in the remaining IV regressions–see OPR (Section 6.4.1.2) on this. In what follows we refer to these as *processed* instruments because they are constructed from a regression. Next the starting values for the MLE procedure are saved in a vector called **"starting_values_mle"** and the output from the SVAR routine is saved as **"svar_output_mle"**

[2]Notice the use of "**_mle_**" in the naming scheme of the workfile objects. It is controlled by the current setting of the output tag, in this case *"mle"* (see above).

in the workfile. Lastly, the estimated values of A, B, S, and F are saved in the current pagefile as **a_mle**, **b_mle**, **s_mle** and **f_mle**.

Algorithm: No Restrictions on the Descriptive VAR

Given zero restrictions in the A, B, S, and F matrices, the add-in works as follows:

1. Suppose $A[i, j]$ is set to a numeric value. Then the coefficient on the j^{th} endogenous (contemporaneous) variable in the i^{th} IV equation will be constrained to that value. It follows that the j^{th} endogenous variable is omitted from the i^{th} equation when $A[i, j]$=0. The unity terms on the diagonal of A, namely $A[i, i] = 1$, imply a normalization, flagging the dependent variable of each IV equation. The number of NA entries in each row of A is the number contemporaneous parameters to be estimated, for which instruments are needed to satisfy the standard order condition for identification of the IV regression. This requires that there are at least as many instruments as there are coefficients in the equation. The required instruments may be actual series in the workfile or generated from other regressions, as explained in the following steps.

2. If $S[i, j] = 0$, then the residuals of the i^{th} equation of the *descriptive* VAR are uncorrelated with the j^{th} *structural* error by assumption and therefore can be used as an instrument in the j^{th} IV regression. See OPR (Section 6.4.4) for a detailed example of this case using the Peersman (2005) model.

3. If $F[i, j] = 0$, then for the i^{th}equation the j^{th} endogenous variable and its associated lags will be replaced with their first difference and the maximum order of the lag in these differenced variables will be reduced by one. The resulting residuals can be used as an instrument in the other IV equations. See OPR (Section 6.4.1.2) for an explanation.

4. The IV parameter estimates are used as starting values for the EViews SVAR routine. The MLE estimates/standard errors will be shown on the screen and saved as an object in the current workfile (see **"svar_output_{output tag}"**)

The add-in works internally as follows. First it determines for each equation the number of contemporaneous parameters that need to be estimated from the A matrix and hence the number of processed instruments required for the order condition to be met. The equations then are ranked according to the number of processed instruments required by equation, starting from lowest to highest. The IV regression requiring the *least* number of processed instruments is estimated first, and its residuals become the first processed instrument available for identifying the remaining equations in the system.

The IV regression with the next smallest required instrument count is then estimated. At this point, the add-in will use the estimated residuals of the IV regressions that were estimated before the active regression, and, depending on the presence and location of the zero restrictions in the S matrix, the residuals of the descriptive VAR.

This process continues until the last structural equation is estimated, using all the residuals generated from the previously estimated equations as instruments–see OPR (Section 6.4.4) for an illustration.

Algorithm: Restrictions on the Descriptive VAR

The algorithim is essentially the same when there are zero restrictions on the lagged variables of the descriptive VAR. Given these restrictions, the add-in assesses whether a processed instrument is valid for the current IV equation. For example, suppose the VAR includes a set of variables that is block exogenous relative to the remaining variables in the system (e.g., it has a domestic and a foreign sector, and the domestic sector does not influence the foreign sector). Processed instruments derived from the endogenous block cannot be used as instruments for variables belonging to the exogenous block and the add-in enforces this requirement. Lastly, restrictions on the exogenous variables of the descriptive VAR are not imposed on the IV regressions because, from a theoretical perspective, zero restrictions on the descriptive VAR do not imply that the same restrictions apply in the structural VAR, and it is the latter we are fundamentally interested in.

Output

We look at the example mentioned earlier with the variables DGDP, R, INFL and RTWI. Here the restrictions give matrices

$$\begin{aligned}
A &= \begin{bmatrix} 1.0 & NA & NA & NA \\ NA & 1.0 & NA & .036 \\ NA & NA & 1.0 & NA \\ NA & NA & NA & 1.0 \end{bmatrix}, B = \begin{bmatrix} NA & 0 & 0 & 0 \\ 0 & NA & 0 & 0 \\ 0 & 0 & NA & 0 \\ 0 & 0 & 0 & NA \end{bmatrix} \\
S &= \begin{bmatrix} NA & 0 & 0 & NA \\ NA & NA & NA & NA \\ NA & NA & NA & NA \\ NA & NA & NA & NA \end{bmatrix}, F = \begin{bmatrix} NA & 0 & 0 & 0 \\ NA & NA & NA & NA \\ NA & NA & NA & NA \\ NA & NA & NA & NA \end{bmatrix}.
\end{aligned}$$

We then estimate the model using IV regressions in the order presented. The internal operation of the add-in is explained under each regression.

1. TSLS DGDP C D_R D_INFL D_RTWI DGDP(-1 TO -4) D_R(-1 TO -3) D_INFL(-1 TO -3) D_RTWI(-1 TO -3) @ C DGDP(-1 TO -4) R(-1 TO -4) INFL(-1 TO -4) RTWI(-1 TO -4) [iv_mle_eqn_1 in the workfile]
   (a) This is the first equation in the SVAR. It is estimated first because it does not require any additional instruments.

(b) DGDP is the dependent variable of the equation, since $A(1,1) = 1$. DGDP(-1 TO -4) R(-1 TO -4) INFL(-1 TO -4) RTWI(-1 TO -4) are included as explantory variables, reflecting the lag order of the descriptive VAR (i.e, 4).

(c) The remaining endogeneous variables (i.e., R, INFL, and RTWI) are included in first difference form (i.e., D_R D_INFL, and D_RTWI), reflecting the zero restrictions in the F matrix (first row), and the maximum lag length for each of the endogenous variables is reduced from 4 to 3.

(d) Because of (b), the first lags of R, INFL and RTWI may be used as instruments for D_R, D_INFL, and D_RTWI, but these are already included in the instrument list (see (c)). The order condition for the IV regression is satisfied and no additional instruments are required.

(e) The residuals of this regression (IV_MLE_RES_EQN_1) may be used to identify the remaining IV regressions in the system. We describe these these residuals as a "processed" instrument compared to a normal variable created outside of the regression steps (e.g., lagged R) .

2. TSLS (R+0.036*RTWI) C DGDP INFL DGDP(-1 TO -4) R(-1 TO -4) INFL(-1 TO -4) RTWI(-1 TO -4) @ C DGDP(-1 TO -4) R(-1 TO -4) INFL(-1 TO -4) RTWI(-1 TO -4) VAR_MLE_RES_EQN_1 IV_MLE_RES_EQN_1 [iv_mle_eqn_2 in the workfile]

   (a) This is the second equation in the SVAR. It is estimated second because it has only 2 contemporaneous variables on the RHS, implying the need for 2 additional intruments, which is less than the number required for IV equations 3 and 4 (see below).

   (b) (R+0.036*RTWI) is the dependent variable of the equation, since $A(2,2) = 1$ and $A(2,4) = 0.036$.

   (c) The residuals from the first equation of the descriptive VAR (VAR_RES_EQN_1) is the first processed instrument. It is a valid instrument because, by assumption, monetary shocks do not affect DGDP in the short-run ($S(1,2) = 0$). The remaining instrument is the processed instrument obtained from Step 1 (i.e., IV_MLE_RES_EQN_1).

   (d) The residuals of this regression (i.e., IV_MLE_RES_EQN_2) can be used to identify the remaining IV regressions in the system.

3. TSLS INFL C DGDP R RTWI DGDP(-1 TO -4) R(-1 TO -4) INFL(-1 TO -4) RTWI(-1 TO -4) @ C DGDP(-1 TO -4) R(-1 TO -4) INFL(-1 TO -4) RTWI(-1 TO -4) VAR_MLE_RES_EQN_1 IV_MLE_RES_EQN_1 IV_MLE_RES_EQN_2 [iv_mle_eqn_3 in the workfile]

   (a) This is the third equation in the SVAR. It is estimated third because it has 3 contemporaneous variables on the RHS, implying the need for 3 additional instruments.

(b) INFL is the dependent variable of the equation, since $A(3,3) = 1$.

(c) The residuals from the first equation of the descriptive VAR (VAR_MLE_RES_EQN_1) is a valid instrument because, by assumption, the demand shock does not affect DGDP contemporaneously ($S(1,3) = 0$). The remaining instruments are the processed instruments obtained from Steps 1 and 2 (i.e., IV_MLE_RES_EQN_1 and IV_MLE_RES_EQN_2).

(d) The residuals of this regression (IV_MLE_RES_EQN_3) can be used to identify the last IV regression in the system.

4. TSLS RTWI C DGDP R INFL DGDP(-1 TO -4) R(-1 TO -4) INFL(-1 TO -4) RTWI(-1 TO -4) @ C DGDP(-1 TO -4) R(-1 TO -4) INF(-1 TO -4) RTWI(-1 TO -4) IV_MLE_RES_EQN_1 IV_MLE_RES_EQN_2 IV_MLE_RES_EQN_3 [iv_mle_eqn_4 in the workfile]

   (a) This is the fourth equation in the SVAR. It is estimated last because it has 3 contemporaneous variables on the RHS, implying the need for 3 additional instruments.

   (b) RTWI is the dependent variable of the equation, since $A(4,4) = 1$.

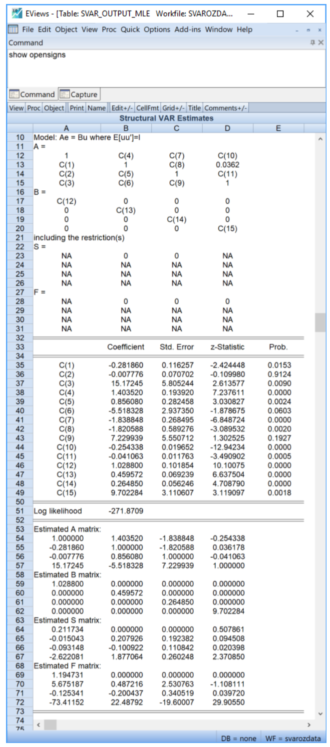
   (c) The 3 instruments (all processed) are the residuals from the other IV regressions (i.e., IV_MLE_RES_EQN_1, IV_MLE_RES_EQN_2 and IV_MLE_RES_EQN_3).

The add-in saves the IV parameter estimates in a vector called **starting_values_mle**, transfers them to the EViews C matrix (which contains the starting values of the coefficients to be estimated) in the correct order, and then invokes the SVAR routine with the following command:

1. OPENSIGNS.SVAR(F0=S,A=A_MAT,B=B_MAT,S=S_MAT,F=F_MAT)[3]

Note that "F0=S" simply instructs EViews to use the starting values in the current C vector of the workfile and the "S" in F0=S has no relation to the S matrix defined earlier. The output is saved in the workfile as a text object called **svar_output_mle**, and the estimated A, B, S, and F matrices are saved in the current pagefile as "**a_mle**", "**b_mle**", "**s_mle**" and "**f_mle**". The actual IV regression commands issued by the add-in are logged in "**iveqns_mle_estimated**".

[3]The add-in actually works with a copy of the VAR object OPENSIGNS called "_OPENSIGNS_" that is created by the add-in. This ensures that the original VAR object is not changed by the workings of the add-in.



Limitations

1. The IV/MLE add-in can handle general numeric restrictions in the A matrix, but only zero restrictions in the S and F matrices.

2. The SVAR must be exactly identified.

3. The add-in does not support restrictions on the exogenous variables of the SVAR. This is due to the fact that zero restrictions on the exogeneous variables of the descriptive VAR do not necessarily imply the same restrictions for the SVAR.

References

1. Ouliaris, S., A. R. Pagan and J. Restrepo (2016), *Quantitative Macroeconomic Modeling with Structural Vector Autoregressions – An EViews Implementation,* available for free download from www.eviews.com

2. Peersman, G. (2005), "What Caused the Early Millennium Slowdown? Evidence Based on Autoregressions," *Journal of Applied Econometrics*, 20, 185-207.