A Guide to the Matlab Toolbox for Interacted Panel VAR estimations (IPVAR)

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Abstract

This is a quick guide to the Matlab estimation function IPVAR which estimates a panel VAR allowing coefficients to vary determinstically with individual characteristics as employed in Towbin and Weber (2011) "'Limits of Floating Exchange Rates: the Role of Foreign Currency Debt and Import Structure"'. The toolbox includes: 1) an equation-by-equation OLS VAR estimator for (unbalanced) Panels with deterministically varying coefficients (IPVAR) 2) An impulse response function generating file which accounts for the presence of interaction terms 3) A generator of bootstrapped parametric or non-parametric confidence intervals for the IRFs (IPVARboot). 4) A simple program which graphs impulse responses (dopics).

There is also a sample file which explains the use of the different functionalities (IPVARexample). All files have a help function which provides the below information.

Contents

1 The General Empirical Framework

The files are in five groups: 1) Estimation, 2) IRF generation 3) Standard Errors and Testing 4) Support Files and 5) Graphical Support programs. The program can accommodate unbalanced panels with missing observations.

All data that is used in any of the files has to be in a standardized order. Each unit (country) needs to have the same time length, if units have different length in the original data missing observations (NaN) need to be used to generate identical time length. The data is hence to be inputted as a matrix of length (Number of Time Periods * Number of Countries) and the number of columns is equal to the number of variables. The data needs to be sorted in the sense that the observations 1 to T are of unit one, T+1 to 2*T of unit 2 and so on.

1.1 Estimation

Our model is an interacted panel VAR with the following recursive form representation:

$$J_{i,t}Y_{i,t} = \tilde{C}_i + \sum_{k=1}^{L} \tilde{A}_k \cdot Y_{i,t-k} + \tilde{C}^1 \cdot X_{i,t} + \sum_{k=1}^{L} \tilde{B}_k^1 \cdot X_{i,t} \cdot Y_{i,t-k} + \tilde{u}_{i,t} \tag{1}$$

$$t = 1, ...T \quad i = 1, ..., N \quad \tilde{u}_{i,t} \sim N(0, \tilde{\Sigma}) \tag{2}$$

where t denotes time and i denotes country. $Y_{i,t}$ is a $q \times 1$ vector of explanatory variables, $\tilde{C}_i$ is a $q \times 1$ vector of country-specific intercepts, $\tilde{A}_{j,k}$ is a $q \times q$ matrix of autoregressive coefficients up to lag L. $\tilde{u}_{i,t}$ is the $q \times 1$ vector of residuals, assumed to be uncorrelated across countries and normally distributed with a $q \times q$ constant covariance matrix $\tilde{\Sigma}$.

$X_{i,t}$ stands for an interaction term that influences the dynamic relationship between the endogenous variables ($\tilde{A}_k^1$) and is also allowed to affect the level of the variables (via $\tilde{C}^1$) . Note that in this model coefficient-variation is parameterized as a function of structural determinants, in contrast to other studies that use single-country VARs with stochastically time-varying coefficients (see, for example, Canova et al. 2007, Cogley and Sargent, 2005 and Primiceri, 2005).

$J_{i,t}$ is a lower triangular $q \times q$ matrix with ones on the main diagonal. The recursive form of the model implies that the covariance matrix $\tilde{\Sigma}$ is diagonal. In analogy to the effect of lagged variables, the contemporaneous effect of the q^{th} ordered variable on the w^{th} ordered variable is modelled as $J_{i,t}(w, q) = J_i(w, q) \cdot Y_{i,t}(q) + J^1(w, q) \cdot X_{i,t} \cdot Y_{i,t}(q)$ for $q < w$, where scalar $J_{i,t}(w, q)$ is the (w, q) element of $J_{i,t}$ and $Y_{i,t}(q)$ is the value of the q^{th} ordered variable at time t in country i. $J^1(w, q)$ are regression coefficients that denote the marginal effect of a change in the respective interaction term on $J_{i,t}(w, q)$. In addition, we have $J_{i,t}(w, q) = 1$ for $q = w$ and $J_{i,t}(w, q) = 0$ for $q > w$, which follows from the lower triangular form.

The mainfile estimation file is `interactpvar.m`. Important inputs include the endogenous variables (`xdata, ydata`), the interaction terms (`Idata`) and the number of countries(`(I)`)

1.1.1 Additional Restrictions

In addition the use has the option to restrict certain parameter, i.e. impose block exogeneity, or homogenous coefficient (coefficient on interaction terms are set to zero using the `restr` matrix, and `hominterc` option. The routine also returns Ftests that allow regarding validity of these restrictions.

1.2 Evaluation: Comparing Responses Across Different Characteristics

In order to compare dynamics and impulse response functions, the interaction terms must be evaluated at specific values. This is done in `evalpvar.m`. The option `value` is a matrix where each column specifies a differen set of values for all interaction terms.

1.3 Rewriting the VAR in Standard Form

`irfprepvar.m` transforms the VAR back into the standard reduced form and standard programs form impulse response function and identification can be used.

In particular, pre-multiplying both sides with $J_{i,t}^{-1}$ allows us to write the VAR model in the familiar reduced form:

$$\begin{aligned} Y_{i,t} &= C_i + C^1 \cdot X_{i,t} + \sum_{k=1}^{L} A_k \cdot Y_{i,t-k} + \sum_{k=1}^{L} B_k^1 \cdot X_{i,t} \cdot Y_{i,t-k} + u_{i,t} \\ t &= 1, ...T \quad i = 1, ..., N \quad u_{i,t} \sim N(0, \Sigma_{it}) \end{aligned} \tag{3}$$

Note that $\tilde{C}_i = J_{i,t} C_i$ and similarly for the other coefficient matrices in (3). $\tilde{u}_{i,t} = J_{i,t} u_{i,t}$ and $V_{it} = J_{i,t}^{-1} \tilde{\Sigma}^{1/2}$ is the Choleski decomposition of the reduced form covariance matrix Σ_{it}.

Estimating the recursive form instead of the reduced form provides a simple way of parameterizing the covariance matrix of the reduced form residual (and therefore the variation in the contemporaneous relationship of the endogenous variables) as a function of country and time-varying structural elements $X_{i,t}$.[1] We can estimate the coefficients using OLS equation-by-equation. Applying the equivalent OLS procedure to the reduced form would keep the contemporaneous correlation (the off-diagonal elements of the covariance matrix) constant. Depending on the application, the recursive model may correspons the structural identification scheme, but also other identification devices such as sign restrictions can be applied. In that case the recursive form is just a way to

[1] Note that all time-series and cross-sectional variation comes from $J_{i,t}$, while $\tilde{\Sigma}$ is constant.

parameterize the variation in the covariance matrix, but not an identification device (see Sá, Towbin and Wieladek, 2011 for an application that uses sign restrictions). [2]

1.4 Impulse Response Functions

`irfcreator` computes impulse response functions based on a Choleski ordering.

1.5 Inference and Bootstrapping

We use bootstrapped standard errors as proposed by Runkle (1987). 1) Estimate (1 by OLS, 2) draw randomly from the matrix of errors $\hat{\varepsilon}_{i,t}$ a vector of errors $\hat{\varepsilon}_{i,\tilde{t}}$ 3) use $\hat{\varepsilon}_{i,\tilde{t}}$ and the initial observations of the sample and the reduced form estimates of $\hat{B}_l$ to simulate $\hat{Y}_{i,1}$.[3] Now repeat step 2 and 3 as many times as there are errors. The artificial sample is then used to re-estimate the coefficients of (1) with which the (cumulative) IRFs are constructed. The bootstrapping program is `IPVARboot`, important parameters include the number of iterations (`nsim`), and whether errors are drawn parametrically from a normal distribution or non parametrically, by drawing repeatedly from the set of obtained residuals `parametric`.

`IRF_IPVAR` computes confidence intervals for impulse and cumulative impulse response based on the bootstraps. Important options include the coverage (`pct`) and whether the confidence intervals are are symmetric or minimize the distance for a given coverage `centered`.

2 The Separate Files

2.1 Estimation

The main estimation file is the file *interactPVAR.m*.

2.1.1 interactPVAR.m.

[beta,sterr,errors, positioner, F]=interactPVAR(ydata,I,lag,Idata,hominterc,restr,demean)

Program produces structural beta coefficients of a Panel VAR which allows for interaction terms. It allows interaction terms but imposes a Choleski structure. Hence, the data needs to be entered according to the ordering. Data needs to be in standard STATA panel form as given by: a time(t)*I -by- nvar(n) matrix, where country observations are stacked below each other:

[2] In principle the reduced form estimates will depend on the ordering of the variables in the recursive VAR. A related issue arises in a stochastically time-varying structural VAR, as discussed in Primiceri (2005). Primiceri notes that the problem could be resolved by estimating the model with several orderings and assessing sensitivity. Note that this is not a problem if the recursive ordering corresponds to the structural ordering.

[3] Different to the original procedure which was not described for the panel VAR context, we draw initial observations panel specific and perform the simulation for each country.

$$ydata = \begin{pmatrix} X_{11} & & \dots & & X_{N1} \\ & \ddots & & & \\ \vdots & & Xji & & \vdots \\ & & & \ddots & \\ X_{1I} & & \dots & & X_{NI} \end{pmatrix}$$

where X_{ji} is a vector of variable j for country i and the length of the vector is t, where t needs to be identical across units. If there are any exogenous (but dynamic) variables (e.g. terms of trade) they need to be in the first columns of data and the number of exogenous variables needs to be mentioned

Inputs are:

- ydata: The endogenous variables
- I: Number of cross-sectional units (e.g. number of countries)
- lag: Number of lags to be used in the estimation
- Idata: Interaction Terms used in the estimation. A matrix of dimensions [I*time - by - # of interaction variables]
- hominterc=1; in the first hominterc the interaction terms have no level effect (useful for blockexogenous variables withhomogenous dynamics and intercepts)
- demean: = 0 Do not demean data; = 1 demean data (fixed effects)
- restr: Is a matrix of size $nvar - by - nvar * (nint + 1)$ with zeros and ones defining for which equation which interaction and variable a restriction is supposed to be applied (ones leading to an exclusion of the interaction/or variable). If there is an interaction in one period it is assumed to be relevant at all lags! restr is of the following form:

$$restr = \begin{pmatrix} restr_{11} & & \cdots & & restn_{1N} \\ & \ddots & & & \\ \vdots & & restr_{ji} & & \vdots \\ & & & \ddots & \\ rest_{1i} & & \cdots & & rest_{NN} \end{pmatrix}$$

Example a 2*2 VAR with two interaction terms would possibly be

$$restr = \begin{pmatrix} rest_{11} & rest_{12} \\ rest_{21} & rest_{22} \end{pmatrix} = \left(\begin{bmatrix} 0 & 1 & 1 \\ 0 & 0 & 0 \end{bmatrix} \begin{bmatrix} 1 & 1 & 1 \\ 0 & 1 & 1 \end{bmatrix} \right)$$

which implies that the dynamics of the first variable are independent of the other variable and the interactions ($rest_{11}$ and $rest_{12}$) and only depends on its own lagged values. The second (endogenous) variable's response to the first variable can vary with the interactions ($rest_{21}$) but its own lagged values have always the same impact ($rest_{22}$) and do not vary with the interactions. Such a structure may stand for a Bivariate VAR of terms of trade and GDP growth, where the terms of trade are only a function of their past values and the response of GDP to terms of trade may vary with the exchange rate regime (1. Interaction) and the degree of debt (2. Interaction). However, the impact of lagged values of GDP on today's GDP is independent of the exchange rate regime and the level of debt.

The outputs are:

- beta: The structural beta coefficients which are ordered in the following way

$$beta = \begin{pmatrix} 0 & \cdots & \cdots & \cdots & 0 & \beta_{01N} \\ \vdots & \ddots & & & \beta_{01(N-1)} & \vdots \\ \vdots & & 0 & & \vdots & \vdots \\ \vdots & & \beta_{01i} & & \vdots & \vdots \\ 0 & & \beta_{02i} & \cdots & \beta_{0(N-2)(N-1)} & \beta_{0(N-1)N} \\ \beta_{111} & & \beta_{11i} & \cdots & \beta_{11(N-1)} & \beta_{11N} \\ \beta_{121} & & \beta_{12i} & \cdots & \beta_{12(N-1)} & \beta_{12N} \\ \vdots & & \vdots & & & \\ \beta_{1N1} & & \beta_{1Ni} & \cdots & \beta_{1N(N-1)} & \beta_{1NN} \\ \beta_{211} & & \beta_{21i} & \cdots & \beta_{21(N-1)} & \beta_{21N} \\ \vdots & & \vdots & & \vdots & \vdots \\ \beta_{LN1} & & \beta_{LNi} & \cdots & \beta_{L(N-1)N} & \beta_{LNN} \\ c_1 & & \cdots & & \cdots & c_N \end{pmatrix}$$

where β_{lji} stands for the beta coefficients of the dependent variable i on the regressor j (and its interactions) at lag l. β_{lji} itself is a vector which registers at its first place the response to variable j, then the coefficient on the interaction*variable-j. const1 is the vector with the intercept coefficient followed by the coefficients on the interaction terms (if included via the values of const). For the former Bivariate VAR example we would have the following output form for the case of one lag:

$$beta = \begin{pmatrix} 0 & \beta_{012} \\ \beta_{111} & \beta_{112} \\ 0 & \beta_{122} \\ c_1 & c_2 \end{pmatrix} = \begin{pmatrix} 0 & \beta_{(y_{012})} \\ 0 & \beta_{(y_{012*interact1})} \\ 0 & \beta_{(y_{012*interact2})} \\ \beta_{(y_{111})} & \beta_{(y_{112})} \\ 0 & \beta_{(y_{112*interact1})} \\ 0 & \beta_{(y_{112*interact2})} \\ 0 & \beta_{(y_{122})} \\ 0 & 0 \\ 0 & 0 \\ const1 & const2 \end{pmatrix}$$

- sterr: The respective standard errors
- errors: The structural errors
- positioner: An indicator variable which registers which observations have been used for the estimation. This matters if there are missing observation and serves as input and various other programs
- F: Result from an F-test for the joint significance of the interaction terms.

2.2 IRF Generation

There are various programs which support the construction of IRFs. Various of these functions may never be specified by the user, but serve as subroutine for other functions (in particular for IRF_IPVAR).

2.2.1 evalpvar.m

evalbeta=evalpvar(beta,values,lag)

Is used to get from the structural coefficients ($\beta-$coefficients) to the coefficients for the specified values of the interaction terms ($\alpha-$coefficients). Evaluates the beta coefficients that are the output of the interactPVAR.m command at the pre-specified values for the interaction terms. Required inputs are

- beta: output of the interactpvar (m-by-n)

- values: pre-specified values for the interaction terms. Matrix of dimension: (# of evaluations - by- # of interactions)
- lag: # of lags in the estimation

2.2.2 irfpreppvar.m

[betairf Pkomega azero]=irfpreppvar(betaeval,fPkomega,lag)

Converts structural coefficients ($\beta-$coefficients) into reduced form equivalents (by inverting the A_0- matrix). Returns the covariance equivalence and reduced form betas from betas which have been produced by the function interactPVAR.m and afterwards evaluated with evalpvar.m. The reduced form betas serve as input in the file IRFcreator.m.

Required inputs are:

- betaeval: The structural betas which have been evaluated for a particular value of the interaction terms (betaeval is the output of the evalpvar.m program)
- fPkomega: is the (co)variance matrix generated by the structural errors from the interactPVAR.m program (the off-diagonal elements are zero).
- lag: The number of lags used in the estimation

The output is given by:

- betairf: Reduced form beta equivalents
- Pkomega: Pkomega equivalent that derives form choleski decomposing the covariance matrix
- azero: The azero matrix (lower diagonal)

2.2.3 IRFcreator.m

[IRF]=IRFcreator(beta,Pkomega,lag,period)

Creates Impulse Response functions from reduced form betas as returned by irfpreppvar.m It is also a sub-routine of IRF_IPVAR.m

Inputs include:

- beta: beta coefficient as returned by PVAR.m or irfpreppvar.m where the form is given by a matrix of dimension (# of var * # of lags) - by - nvar
- Pkomega: The Covariance matrix as given by PVAR.m or irfpreppvar.m
- lag: # of lags used i n the estimation

- period: Wished length of the period for which the IRF is computed

Output:

- IRF: The impulse responses, a matrix of dimension (# of periods,# of responses, # of shocks)

2.3 Standard Errors and Testing

Standard errors are based on bootstrap method. The relevant programs after interactPVAR.m are IPVARboot.m and IRF_IPVAR.m.

2.3.1 IPVARboot.m

[BETAMAT ERRORMAT STERRMAT] = IPVARboot(parametric,positioner,...
....Idata,ydata,errors,beta,nsim,I,lag,restr,hominterc,demean)

Creates repeated structural beta estimates which are required to generate confidence intervals for the impulse responses of the interaction Panel VAR. The program generates bootstrapped structural beta coefficients and errors by simulating repeatedly the dataset and reestimating the structural coefficients on the bootstrapped samples. The program requires various inputs also specified for the interactPVAR.m program to estimate the point estimates of the original data. The output can be used to construct confidence intervals for the point estimates of interactPVAR.

Inputs include:

- parametric: is a 0 - 1 variable where 1 stands for parametric errors and 0 for non parametric error drawings
- positioner: Indicates where the errors for a new country start and begin
- Idata: The interaction terms, matrix of dimension (I*times - by - # of interactions)
- ydata: The y-variable matrix used in the estimation of interactPVAR. ydata=xdata if there have been no restriction on the data.
- errors: The structural errors (output from interactPVAR.m)
- beta: The structural beta estimates as produced by interactPVAR.m
- nsim: Is the number of draws for re-estimation (usually 100-500). The fewer the faster, though the less accurate.
- I: Number of countries (=1 implies one country $\rightarrow$ no panel)
- lag: Number of lags used in the estimation

- restr: The matrix of restrictions specified for the estimation See interactPVAR.m
- hominterc=1; in the first hominterc the interaction terms have no level effect (useful for blockexogenous variables withhomogenous dynamics and intercepts)
- demean: = 0 Do not demean data; = 1 demean data (fixed effects)

Outputs incldue:

- BETAMAT: The matrix of structural beta estimates of dimension [size(beta,1)), size(beta,2),number]
- ERRORMAT: The matrix of structural errors of dimension [size(errors,1)), size(errors,2),number]
- STERRMAT: The matrix of structural beta estimates of dimension [size(beta,1)), size(beta,2),number]

The routine calls on the functions: interactPVAR.m , gapfill.m.

2.3.2 IRF_IPVAR.m

[IRF,STD,CUMSTD,decomp,IMEAN,CUMIMEAN]
= IRF_IPVAR(BETAMAT,ERRORMAT,lag,values,period,pct,centered)

Uses Output from the Bootstrap function IPVARboot to create IRFs at different evaluations and the respective confidence intervals.

The inputs are:

- BETAMAT: Structural betas from the IPVARboot output
- ERRORMAT: Structural errors from the IPVARboot output
- lag: number of lags
- values: Values at which the interaction terms should be evaluated
- period: The number of periods for which the IRFs should be drawn
- pct: The extent of the Confidence interval mistake (i.e. 5 or 10)
- centered: if 0 normal CIs are drawn if 1 CIs are the (1-pct) range which minimizes the distance between upper and lower bound

The outputs are:

- IRF: The impulse responses of all bootstraps
- STD: The lower and upper CI of the IRF

- CUMSTD: The lower and upper CI for the cumulative IRF
- decomp: The variance decomposition
- IMEAN: The mean of the bootstrapped IRF
- CUMIMEAN: The mean of the bootstrapped cumulative IRF

The routine calls on the functions: evalpvar.m, irfpreppvar.m, IRFcreator.m, minprctile.m

2.3.3 minprctile.m

[U L]=minprctile(X,pctile)

Chooses the respective confidence intervals based on the minimum distance criteria. The function returns the upper and lower value of the values in X which define the (1-pctile) percent of the values contained in the vector X. Rather than taking the 2.5% and 97.5 limits in the case of pctile=5, the values L and U are chosen to minimize the distance of U and L maintaining the area between U and L equal to 1-pctile.

2.3.4 irftest.m

diffirfparam=irftest(irfbs,ma,var,shock)

2.4 Support Files

Some files are provided to facilitate the manipulation of data in a panel context.

2.4.1 panellag.m

[output] = panellag(data,I,length)

This function serves to lag the data by as many lags as whished taking account of the fact that the vector has a time and unit dimension. Required inputs are

- data: The panel data with dimension (time*I - by- variables)
- I: number of cross sectional units
- length: the number of lags that should be taken from the data

The output is a matrix of dimension (time*I - by- variables) with the lagged data.

2.4.2 paneldiff.m

[output] = paneldiff(data,I)

Serves to take the first difference of the data which can be entered as a panel of various variables. Required input data includes:

- data: a matrix of dimension (time*I -by- variables)
- I: number of cross sectional units

The output is the first differenced data of dimension (time*I -by- variables).

2.4.3 paneldetrend.m

[output] = paneldetrend(data,I, power)

Allows various modes to detrend the data. which are defined by the input power. If power=0 the data is demeaned, i power=1, linear detrending is used and if power=2 a quadratic trend is used. Other inputs include:

- I: Is the cross sectional dimension
- data: Is the panel data with dimension (time*I -by- variable)

The output is the detrended data of dimension (time*I -by- variables).

2.4.4 gapfill.m

Y=gapfill(X,varargin)

Is a support file for the bootstrap method with interaction terms to address missing values in the interaction terms. The function interpolates data and adds data at the beginning and end of the vector X if there are NaNs. For instance: If only internal values are supposed to be interpolated use Y = gapfill(X, 'method'). If also the endings should be interpolated use Y = gapfill(X, 'method1', 'method2') where method 1 is the method applied to the internal values and method2 is the method applicable to the missing values at the end and begininng of the vector. See 'interpol1.m' for a desctiption of possible methods

2.5 Graphical Support

Generally the user is interested in the graphical representation of the impulse responses including the confidence intervals. We provide a predefined program to depict the impulse responses for the differnt evaluatins of the interaction terms in response to a shock in one graph.

2.5.1 dopics.m

dopics(MA,STD,CUMSTD,shock,cum,period,values,nvar)

Graphs the (cumulative) IRF and confidence bands for the responses of all variables in the system to a specified shock, for all evaluations of the interaction terms:

- MA: MA is period x Number of IRs matrix and stands for the IRS that should be comparded in a row
- STD: STD is a period x 2 matrix Numbber of IRs and contains the
- CUMSTD: The lower and upper CI for the cumulative IRF
- shock: The shock number for which the impulse response is drawn.
- cum: Defines whether impulse response functions are accumulated (=1) or not (=0).
- period: The number of periods for which the IRFs are plotted.
- values: Values at which the interaction terms should be evaluated
- nvar: The number of endogenous variables in the estimation.

The output is the graph itself. The routine calls on the function: impcompare.m

2.5.2 impcompare.m

impcompare(MA,STD,line,nvar,numpic,shock)

Subroutine to dopics.

3 An Example

To illustrate the application of the programs we make use of a sub-sample as in Towbin and Weber (2009). The data is available saved under the name data.m. The file to run the whole sequence is called IPVARexample.m.

```
%%--------- MANUAL PART ------------
%% DATA MANIPULATION
clear
close all

%% Loading in the Data
%addpath 'C:\Users\SWeber\IPVARtoolbox\IPVAR'
load data

%% Defining Variables
tot=data(:,1);
inv=data(:,2);
gdp=data(:,3);

debt=data(:,4);
exrate=data(:,5);

ifscode=data(:,6);
year=data(:,7);

%% Setting Estimation Properties

lag = 2;         % Number of lags
hominterc=1;     % in the first hominterc the interaction terms have no level effect
                 % (useful for blockexogenous variables withhomogenous dynamics and
                 % intercepts)
I=109;           % Number of countries
pct=10;          % Confidence level for the CI-bands (default =10)
nsim=20;         % Number of simulations for the bootstrapped
                 % confidence bands (default = 200)
centered=0;      % If = 0 symmetric CIs are reported if = 1 CIs are the (1-pct) range
                 % which minimizes the distance between upper and
                 % lower bound (default =0)
parametric=1;    % 1 = CI based on drawings of standards errors are drawn from normal
                 % distribution, otherwise from observed errors
                 % (default = 1)
period=10;       % Number of periods for which IRF is calculated (default = 10)
demean=1;        % 1 = fixed effects (default = 1)
cum=1;           % cumulative IRFs = 1 (default = 1)
shock=1;         % Graph IRF in response to shock in variable # 1,2,3....nvar

%% Define Regressors
% first differences of the log of the data while taking account of the
% panel nature of the data
ydata=[paneldiff(log(tot*100),I)  paneldiff(inv,I) paneldiff(gdp,I)];

%% Define Matrix of Interaction Terms
Idata=[exrate debt exrate.*debt];

%% Setting Restrictions on Interaction Terms
% Three equation, three interaction variable and, first variable exogenous.
```

```
restr = [0 1 1 1 1 1 1 1 1 1 1 1
         0 0 0 0 0 0 0 0 0 0 0 0
         0 0 0 0 0 0 0 0 0 0 0 0];
%see interactpvar for a description for no restrictions on dynamics set
%restr=zeros(size(ydata,2), size(Idata,2)*size(Idata,2));

%% Defining values at which interaction terms are to be evaluated for the IRF
values=[1 prctile(Idata(:,2),75) prctile(Idata(:,2),75)
        0 prctile(Idata(:,2),75) 0
        1 prctile(Idata(:,2),25) prctile(Idata(:,2),25)
        0 prctile(Idata(:,2),25) 0];
    values=values';

%% START AUTOMATIC PART ----------------------
nint=size(Idata,2);   % number of interaction terms
nvar=size(ydata,2);   % number of ebndogenous variables

%% Estimation of Structural Form
[beta,sterr,errors, positioner, F]=interactPVAR(ydata,I,lag,Idata,hominterc,....
    restr,demean);

%% Variance of (orthogonal) Shocks
for i=1:nvar
fPkomega(i,i) = errors(:,i)'*errors(:,i)/(size(errors,1)-(size(find(beta(:,i)),1)));
end

%% Create IRF for different interaction term values
for i=1:size(values,2)
    betaeval(:,:,i)=evalpvar(beta,values(:,i),lag);
    [betairf(:,:,i) Pkomega(:,:,i) azero(:,:,i)]=irfpreppvar(betaeval(:,:,i)...
        ,fPkomega,lag);
    MA(:,:,:,i)=IRFcreator(betairf(:,:,i),Pkomega(:,:,i),lag,period);
end

%% Create bootstrapped confidence bands
% Create bootstrapped structural betas
[BETAMAT ERRORMAT STERRMAT]=IPVARboot(parametric,positioner,Idata,....
    ydata,errors,beta,nsim,I,lag,restr,hominterc,demean);

% Create bootstrapped IRFs
[IRF,STD,CUMSTD,decomp,IMEAN,CUMIMEAN]=IRF_IPVAR(BETAMAT,ERRORMAT,lag,values,....
    period,pct,centered);

%% Generating Pictures
dopics(MA,STD,CUMSTD,shock,cum,period,values,nvar)

%% END AUTOMATIC PART
```

4 A Word of Caution

These files are for free personal use and manipulation. We hope to have eliminated any possible bugs, though we can not guarantee for this. The user should also keep in mind the limitations of the use of this estimation approach. In particular it is important for the results to be meaningful that stationarity is preserved. This is particular critical when using interactions. Although, the program can deal with missing values non stationary interaction terms can cause problems in particular for the calculation of the confidence intervals since these are based on bootstraped samples which draw errors from the sample errors.