VAR specifications for Exports and Imports of Italy

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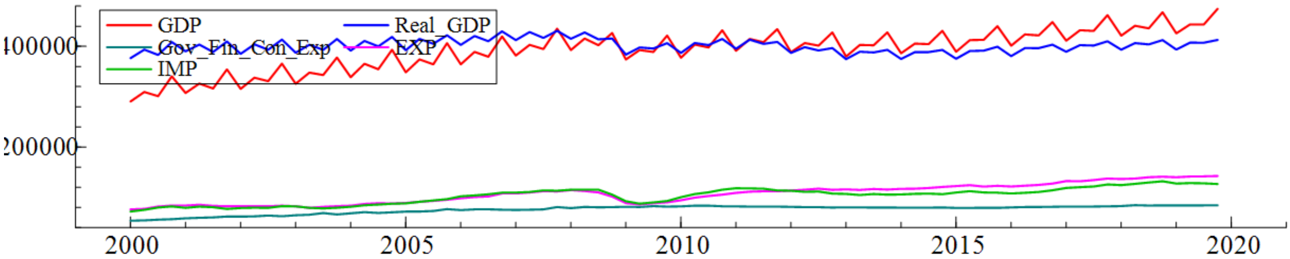
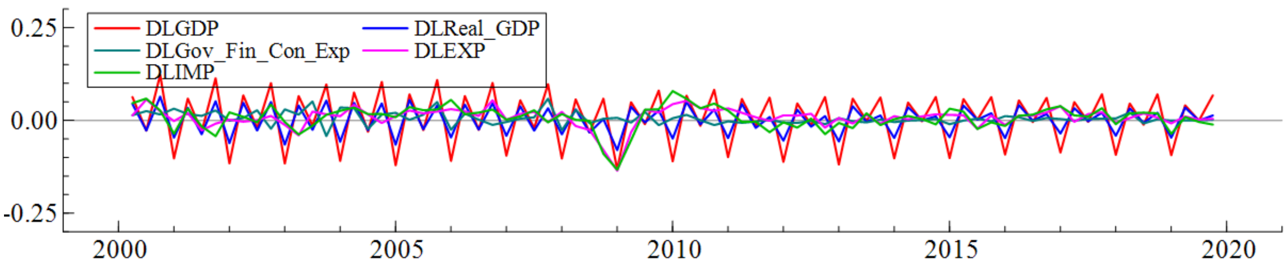
I will use quarterly data from the last 20 years (from the 1st quarter of 2000 to the last quarter of year 2019) from the series of GDP, Real GDP, Export, Import and Government Spending for Italy.

A first thing to do would be to plot the Actual series:



As we can see, **Export and Import series behave in a similar way**. Also, GDP and Real GDP have some similarities and it is interesting to notice that after a long "chase", GDP "reached" the amounts of Real GDP during the times of the 2008 financial crisis, and finally grew higher right after the crisis. Also, **<u>GDP and Real GDP series present autocorrelation (seasonality) clearly</u>**.

Now, we can calculate the first differences of each series and present the related Actual series:



At a first glance, this graph is not very explanatory, apart than for DLGDP and DLReal_GDP; the seasonality that was visible in the previous graph is more accentuated here. So, we could do a separate graph for DLEXP and DLIMP:

We can see that here there is little seasonality in these two series, but we will check it. **<u>We will try to create VAR specifications for these two series</u>**, but first, **we will make Unit root tests for all original series and their first differences**. We can do this through the Descriptive Statistics using PcGive. We check for a constant and trend, because we observed a kind of trend in the Actual series and seasonals, which takes into account the seasons within data. Lag length is set to 3:

```
Unit-root tests
The sample is: 2001(2) - 2019(4) (79 observations and 10 variables)

GDP: ADF tests (T=75, Constant+Trend+Seasonals; 5%=-3.47 1%=-4.08)
D-lag    t-adf      beta Y_1    sigma   t-DY_lag  t-prob       AIC  F-prob
  3     -1.667       0.93384    4143.     -1.385  0.1706     16.77
  2     -1.768       0.92958    4171.      1.380  0.1721     16.77  0.1706
  1     -1.732       0.93058    4199.    -0.9826  0.3293     16.77  0.1540
  0     -1.822       0.92724    4198.                        16.76  0.1945

Real_GDP: ADF tests (T=75, Constant+Trend+Seasonals; 5%=-3.47 1%=-4.08)
D-lag    t-adf      beta Y_1    sigma   t-DY_lag  t-prob       AIC  F-prob
  3     -1.391       0.92467    4312.     -2.683  0.0092     16.85
  2     -1.924       0.89364    4507.      2.899  0.0051     16.93  0.0092
  1     -1.438       0.91717    4746.     -2.467  0.0161     17.02  0.0007
  0     -2.082       0.88005    4918.                        17.08  0.0001

Gov_Fin_Con_Exp: ADF tests (T=75, Constant+Trend+Seasonals; 5%=-3.47 1%=-4.08)
D-lag    t-adf      beta Y_1    sigma   t-DY_lag  t-prob       AIC  F-prob
  3     -2.014       0.93374    1084.      1.440  0.1547     14.09
  2     -2.193       0.92783    1093.     -1.044  0.3004     14.09  0.1547
  1     -2.113       0.93065    1094.     -3.904  0.0002     14.08  0.2117
  0     -2.071       0.92541    1201.                        14.26  0.0009

EXP: ADF tests (T=75, Constant+Trend+Seasonals; 5%=-3.47 1%=-4.08)
D-lag    t-adf      beta Y_1    sigma   t-DY_lag  t-prob       AIC  F-prob
  3     -3.750*      0.81823    2253.      1.068  0.2894     15.55
  2     -3.629*      0.83962    2256.      1.857  0.0677     15.54  0.2894
  1     -3.119       0.86899    2296.      5.222  0.0000     15.57  0.1085
  0     -1.806       0.91265    2698.                        15.88  0.0000

IMP: ADF tests (T=75, Constant+Trend+Seasonals; 5%=-3.47 1%=-4.08)
D-lag    t-adf      beta Y_1    sigma   t-DY_lag  t-prob       AIC  F-prob
  3     -3.213       0.85248    2724.     0.4254  0.6719     15.93
  2     -3.299       0.85947    2707.      1.217  0.2280     15.91  0.6719
  1     -3.057       0.87720    2717.      5.418  0.0000     15.90  0.4442
  0     -1.696       0.92068    3227.                        16.24  0.0000

DLGDP: ADF tests (T=75, Constant+Trend+Seasonals; 5%=-3.47 1%=-4.08)
D-lag    t-adf      beta Y_1    sigma   t-DY_lag  t-prob       AIC  F-prob
  3     -2.730       0.40791 0.009486     -5.027  0.0000    -9.204
  2     -5.958**    -0.22635  0.01107      2.475  0.0158    -8.906  0.0000
  1     -5.255**    0.027710  0.01148     -3.064  0.0031    -8.845  0.0000
  0     -13.33**    -0.44456  0.01216                       -8.743  0.0000

DLReal_GDP: ADF tests (T=75, Constant+Trend+Seasonals; 5%=-3.47 1%=-4.08)
D-lag    t-adf      beta Y_1    sigma   t-DY_lag  t-prob       AIC  F-prob
  3     -3.025       0.34668 0.009436     -4.905  0.0000    -9.214
  2     -6.481**    -0.29329  0.01094      2.945  0.0044    -8.930  0.0000
  1     -5.490**   0.0090179  0.01154     -2.256  0.0273    -8.835  0.0000
  0     -11.33**    -0.30989  0.01188                       -8.790  0.0000

DLGov_Fin_Con_Exp: ADF tests (T=75, Constant+Trend+Seasonals; 5%=-3.47 1%=-4.08)
D-lag    t-adf      beta Y_1    sigma   t-DY_lag  t-prob       AIC  F-prob
  3     -3.715*     -0.13939  0.01513    -0.9036  0.3695    -8.270
  2     -4.744**    -0.27297  0.01511     -1.710  0.0919    -8.285  0.3695
  1     -7.919**    -0.58404  0.01532     0.9508  0.3450    -8.269  0.1627
  0     -13.22**    -0.42379  0.01531                       -8.282  0.2090

DLEXP: ADF tests (T=75, Constant+Trend+Seasonals; 5%=-3.47 1%=-4.08)
D-lag    t-adf      beta Y_1    sigma   t-DY_lag  t-prob       AIC  F-prob
  3     -4.614**     0.33207  0.02352      2.451  0.0169    -7.388
  2     -3.811*      0.48073  0.02438     0.3200  0.7500    -7.327  0.0169
  1     -4.102**     0.49962  0.02422   -0.09874  0.9216    -7.352  0.0537
  0     -4.837**     0.49356  0.02405                       -7.379  0.1164
```

```
DLIMP: ADF tests (T=75, Constant+Trend+Seasonals; 5%=-3.47 1%=-4.08)
D-lag     t-adf      beta Y_1    sigma   t-DY_lag  t-prob       AIC  F-prob
  3      -4.570**     0.30588  0.02805      2.045  0.0448    -7.035
  2      -3.994*      0.44459  0.02871     0.3897  0.6980    -7.000  0.0448
  1      -4.334**     0.46982  0.02853     0.1754  0.8613    -7.025  0.1222
  0      -4.988**     0.48088  0.02833                       -7.051  0.2341
```

Before starting to examine the values, let's recall that for a unit root test such as ADF Test (which is used in this case) the hypotheses are as follows:

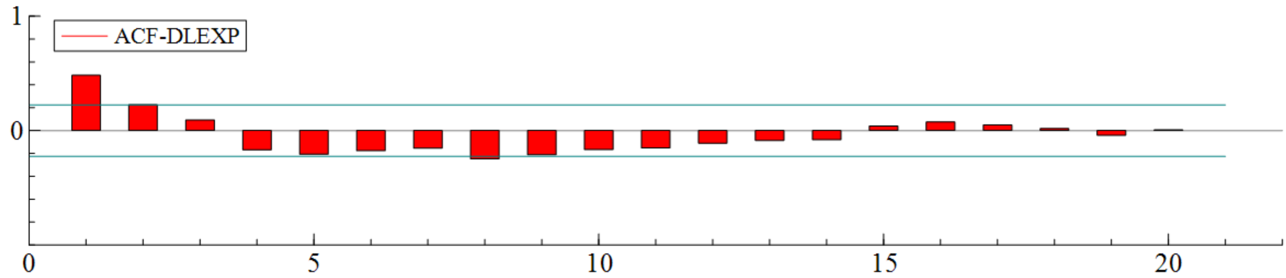
$$H_0: \textit{There is a unit root in the series, the process is non} - \textit{stationary.}$$

$$t_{emp} > t_{crit}$$

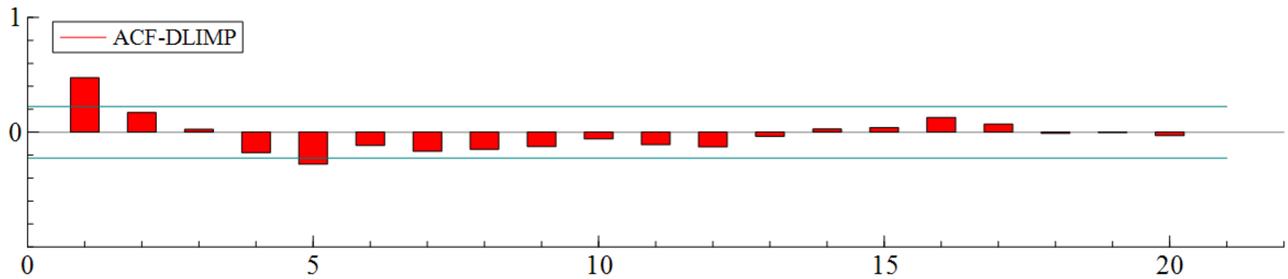
$$H_1: \textit{There is no unit root in the series, the process is stationary.}$$

$$t_{emp} < t_{crit}$$

We can see that **among the original series <u>only Exports are stationary</u>**, strangely, if 2 or 3 lags are used, but not if none is used. **Looking at the first differences, there is <u>stationarity at almost every lag</u>.** Now, we can check for seasonality in the first differences of Export and Import. To do so, we will plot time-series separately, starting with the ACF for DLEXP:

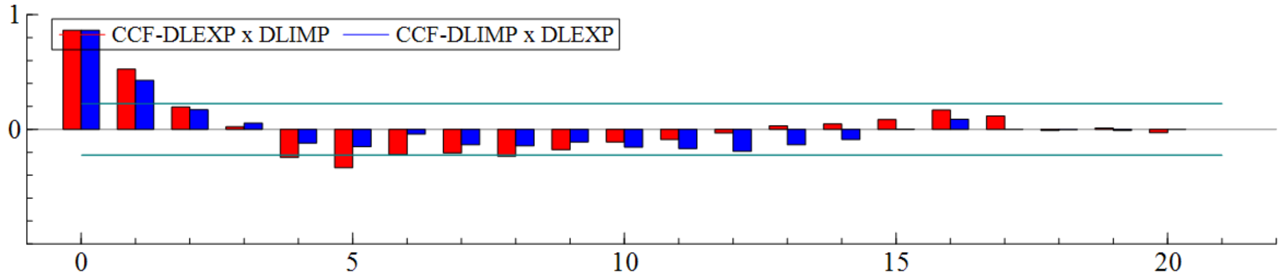


We can see that the **1st, 2nd and 8th lags present statistically significant autocorrelation**. The 5th lag is on the edge. For the first lag, the value is positive, which means that if in the previous quarter there was a low negative value, in the current one we have a higher one. The 8th lag instead, which is negative, could be interpreted by saying that if we had a positive value in the first quarter, then in the current one we have a lower value.
If we look at the ACF for DLIMP:



We can see a similar pattern, but only the 1st and 5th lags are statistically significant.

Also, we can look at the Cross-Correlation function for the two series:



We can see that the red bars represent the correlation of DLEXP with DLIMP, while the blue bars represent the correlation of DLIMP with DLEXP. To give an interpretation: the first red bar represents the correlation between DLEXP in time t and DLIMP in time t, while the second red bar represents the correlation between DLEXP in time t and DLIMP in time (t-1) and so on. So, **the first series is always stable in time t, while the second series moves "backwards" in time**.

Now, we can make other descriptive statistics for the first differences only this time. We will create means, standard deviations and correlations, setting the length of the correlogram to 12 quarters. We would like to focus on the **correlation matrix**:

```
Means, standard deviations and correlations
The sample is: 2000(2) - 2019(4) (79 observations and 5 variables)
Correlation matrix:
                          DLGDP   DLReal_GDPDLGov_Fin_Con_Exp          DLEXP          DLIMP
DLGDP                    1.0000      0.95578      0.058561       0.10004       0.070025
DLReal_GDP              0.95578       1.0000     0.0089327       0.17057        0.14985
DLGov_Fin_Con_Exp      0.058561    0.0089327        1.0000     -0.037111      -0.066994
DLEXP                   0.10004      0.17057     -0.037111        1.0000        0.86551
DLIMP                  0.070025      0.14985     -0.066994       0.86551         1.0000
```

We can see that this is a **symmetric matrix**; the values on the diagonal correspond to the correlation of a series with itself, which equals 1. So, we can see that for example, DLEXP has a quite strong correlation with DLIMP (0.86551), while the first differences of government expenditures are barely correlated with anything (the value is always close to zero whatever the second series is).

We can start modelling now. At first, **<u>we will create 2 autoregressive processes for Export and Import separately</u>**. We will move towards the joint approach just later.

So, let's start with the models for DLEXP series; we will use Single-equation Dynamic Modelling using PcGive as a Model class, Dynamic linear regression model as a Model type and OLS as estimation method. We start with just the 1st lag, since we had seen that the 1th lag was statistically significant in the ACF graph for DLEXP:

```
EQ( 1) Modelling DLEXP by OLS
       The estimation sample is: 2000(3) - 2019(4)

                  Coefficient  Std.Error  t-value  t-prob Part.R^2
DLEXP_1              0.483939     0.1004     4.82  0.0000   0.2343
Constant           0.00399214   0.002807     1.42  0.1590   0.0259

sigma               0.0237594  RSS            0.0429027348
R^2                  0.234289  F(1,76) =      23.25 [0.000]**
Adj.R^2              0.224214  log-likelihood       182.038
no. of observations        78  no. of parameters          2
mean(DLEXP)        0.00784782  se(DLEXP)          0.0269752
```

```
AR 1-5 test:       F(5,71)   =   1.0843 [0.3766]
ARCH 1-4 test:     F(4,70)   =   3.2738 [0.0161]*
Normality test:    Chi^2(2)  =   16.425 [0.0003]**
Hetero test:       F(2,75)   =   8.7934 [0.0004]**
Hetero-X test:     F(2,75)   =   8.7934 [0.0004]**
RESET23 test:      F(2,74)   =   3.0143 [0.0551]
```

As we can see, the **1st lag is statistically significant**, together with the constant. R^2 is equal to 0.234289, which is very low. Some issues are presented by the tests' outcome: **we have ARCH effect, non-normally distributed residuals** and according to the hypotheses for the Hetero test:

$$H_0: Residuals\ are\ homoscedastic$$

$$t_{prob} > 0.05$$

$$H_1: Residuals\ are\ heteroscedastic$$

$$t_{prob} < 0.05$$

We have heteroscedastic residuals. Regarding the RESET23 test:

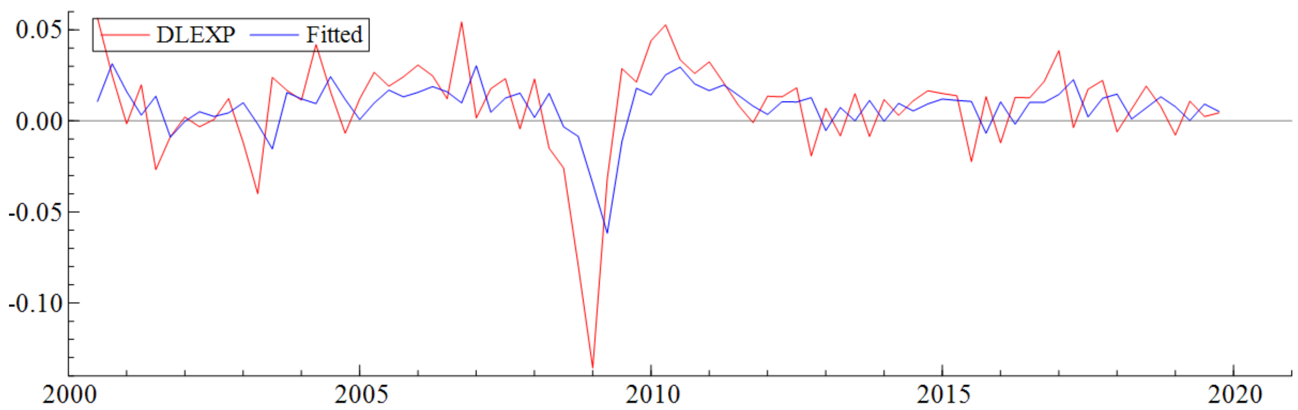
$$H_0: A\ linear\ specification\ is\ a\ proper\ one\ for\ this\ process$$

$$t_{prob} > 0.05$$

$$H_1: A\ linear\ specification\ is\ not\ a\ proper\ one\ for\ this\ process$$

$$t_{prob} < 0.05$$

So, we can see that the linear form is proper (barely) for this specification. The graphical representation of the model is as follows:



We can see that the DLEXP series is not perfectly fitted. Later, there will be a need to use the outlier and break detection, pretty surely, so as to add a dummy variable at least. For now, we can try to create a model with 8 lags, and see if the increase of parameters will improve the outcome:

```
EQ( 2) Modelling DLEXP by OLS
       The estimation sample is: 2002(2) - 2019(4)

                  Coefficient  Std.Error  t-value  t-prob Part.R^2
DLEXP_1              0.490114     0.1226     4.00  0.0002   0.2051
DLEXP_2            -0.0139469     0.1367   -0.102  0.9191   0.0002
DLEXP_3             0.0936407     0.1352    0.693  0.4912   0.0077
DLEXP_4             -0.284313     0.1354    -2.10  0.0398   0.0664
DLEXP_5           -0.00561774     0.1332  -0.0422  0.9665   0.0000
DLEXP_6           -0.00797692     0.1327  -0.0601  0.9523   0.0001
DLEXP_7              0.100541     0.1308    0.769  0.4450   0.0094
DLEXP_8             -0.253197     0.1183    -2.14  0.0363   0.0688
Constant           0.00687094   0.003234     2.12  0.0376   0.0679

sigma               0.0232835  RSS              0.0336115807
R^2                  0.348994  F(8,62) =      4.155 [0.001]**
Adj.R^2              0.264993  log-likelihood        171.028
no. of observations        71  no. of parameters           9
mean(DLEXP)        0.00768547  se(DLEXP)           0.0271583

AR 1-5 test:      F(5,57)   =  0.40362 [0.8443]
ARCH 1-4 test:    F(4,63)   =   2.5417 [0.0483]*
Normality test:   Chi^2(2)  =   18.930 [0.0001]**
Hetero test:      F(16,54)  =   1.4655 [0.1478]
Hetero-X test:    F(44,26)  =   5.5903 [0.0000]**
RESET23 test:     F(2,60)   =   1.4387 [0.2453]
```

As we can see, only the 1st **and the 8th lag are significant for this model**. On one hand**,** R^2 **has increased little**, while **log-likelihood is now lower**. The **tests show slightly better outcome** as **<u>ARCH effect has been almost removed</u>**, while the **<u>Hetero test shows that the residuals are homoscedastic now</u>** (the Hetero-X-test doesn't agree). Unfortunately, the **residuals are still non-normal**. This specification is not a good one.

<u>Could it be that the very negative outlier which was visible in the previous graphs is influencing our models in such a strong way</u>? If we look at the dataset:

	observation_date	GDP	Real_GDP	Gov_Fin_Con_Exp	EXP	IMP	DLGDP	DLReal_GDP	DLGov_Fin_Con_Exp	DLEXP
2008(4)	2008(4)	426754	415648.	80619.5	101419.	105369.	.058777	.00391432	.00447667	-.0794167
2009(1)	2009(1)	374035	383732	81197.9	88554.5	92269.8	-.131858	-.0798948	.00714883	-.135639

We can see that there are two strongly negative values for DLEXP, in the 4th quarter of 2008 and in the subsequent quarter. We could try to add dummy variable to account for these two values. **Let's do this**. Those negative values are very likely to be related with the global crisis.

After the creation of a dummy variable for the period from 2008(4) to 2009(1), we can create a model in which we leave only the 1st and 8th lags for DLEXP; we have seen that those lags were the only significant ones in our previous estimation. The model turns out as:

```
EQ(52) Modelling DLEXP by OLS
       The estimation sample is: 2002(2) - 2019(4)

                  Coefficient  Std.Error  t-value  t-prob Part.R^2
DLEXP_1              0.245743    0.08313     2.96  0.0043   0.1154
DLEXP_8             -0.141077    0.07475    -1.89  0.0634   0.0505
Constant           0.00980409   0.002326     4.21  0.0001   0.2096
dummy1+2            -0.100452    0.01347    -7.46  0.0000   0.4535

sigma               0.0173323  RSS              0.0201273267
R^2                  0.610164  F(3,67) =      34.96 [0.000]**
```

```
Adj.R^2                 0.592708  log-likelihood        189.232
no. of observations           71  no. of parameters           4
mean(DLEXP)           0.00768547  se(DLEXP)           0.0271583

AR 1-5 test:      F(5,62)   =   2.2363 [0.0617]
ARCH 1-4 test:    F(4,63)   =  0.50233 [0.7341]
Normality test:   Chi^2(2)  =  0.59696 [0.7419]
Hetero test:      F(5,65)   =  0.61011 [0.6924]
Hetero-X test:    F(6,64)   =  0.50787 [0.8002]
RESET23 test:     F(2,65)   =   2.6545 [0.0779]
```

We can already see that this is a good specification, parametrically and diagnostically speaking. The 1st lag, a Constant and the dummy variable are significant, however, the 8th lag is not significant anymore. The value of R^2 **<u>has almost doubled (!) while log-likelihood as also increased</u>**. Now, there is no autocorrelation within 5 lags, no ARCH effect, the residuals are normal and homoscedastic, and the linear form is proper for the specification. **<u>All the tests are positive</u>**. This is the best specification obtained so far for DLEXP. Let's look at the graphical representation:

Visibly, the fit is not the best yet, but there has been a nice improvement, especially in the area of the outlier.
However, we should also try to use the Automatic model selection and see if a better model can be created.

We will use the Automatic model selection tool, starting with 8 lags:

```
GUM( 3) Modelling DLEXP by OLS
        The estimation sample is: 2002(2) - 2019(4)

                  Coefficient  Std.Error  t-value  t-prob Part.R^2
DLEXP_1              0.490114     0.1226     4.00  0.0002   0.2051
DLEXP_2            -0.0139469     0.1367   -0.102  0.9191   0.0002
DLEXP_3             0.0936407     0.1352    0.693  0.4912   0.0077
DLEXP_4             -0.284313     0.1354    -2.10  0.0398   0.0664
DLEXP_5           -0.00561774     0.1332  -0.0422  0.9665   0.0000
DLEXP_6           -0.00797692     0.1327  -0.0601  0.9523   0.0001
DLEXP_7              0.100541     0.1308    0.769  0.4450   0.0094
DLEXP_8             -0.253197     0.1183    -2.14  0.0363   0.0688
Constant           0.00687094   0.003234     2.12  0.0376   0.0679

sigma                0.0232835  RSS             0.0336115807
R^2                   0.348994  F(8,62) =      4.155 [0.001]**
Adj.R^2               0.264993  log-likelihood        171.028
no. of observations         71  no. of parameters           9
mean(DLEXP)         0.00768547  se(DLEXP)           0.0271583

AR 1-5 test:      F(5,57)   =  0.40362 [0.8443]
```

```
ARCH 1-4 test:    F(4,63)   =   2.5417 [0.0483]*
Normality test:   Chi^2(2)  =   18.930 [0.0001]**
Hetero test:      F(16,54)  =   1.4655 [0.1478]
Chow test:        F(20,42)  =  0.30190 [0.9973]   for break after 2014(4)

---------- Autometrics: dimensions of initial GUM ----------
no. of observations       71  no. of parameters          9
no. free regressors (k1)    9  no. free components (k2)    0
no. of equations            1  no. diagnostic tests       5

[0.2] Presearch reduction of initial GUM

Starting closed lag reduction at 0.11413
Removing lags(#regressors): none

Starting common lag reduction at 0.11413
Removing lags(#regressors): 5-5(1) 6-6(1) 2-2(1) 3-3(1)

Starting common lag reduction at 0.11413 (excluding lagged y's)
Removing lags(#regressors): none

Presearch reduction in opposite order

Starting common lag reduction at 0.11413 (excluding lagged y's)
Removing lags(#regressors): none

Starting common lag reduction at 0.11413
Removing lags(#regressors): 5-5(1) 6-6(1) 2-2(1) 3-3(1)

Starting closed lag reduction at 0.11413
Removing lags(#regressors): none

Encompassing test against initial GUM (iGUM) removes: none

Presearch reduction: 4 removed,  LRF_iGUM( 4) [0.9711]
Presearch removed: DLEXP_2 DLEXP_3 DLEXP_5 DLEXP_6

[0.3] Testing GUM 0:  LRF( 5) [0.0000] kept

[1.0] Start of Autometrics tree search

Searching from GUM 0  k=   5 loglik=     170.732

Searching for contrasting terminals in terminal paths

[2.0] Selection of final model from terminal candidates: terminal 0

p-values in Final GUM and terminal model(s)
                 Final GUM
DLEXP_1         0.00000663
DLEXP_4         0.01998094
DLEXP_7         0.47688571
DLEXP_8         0.02928084
Constant        0.02402573
k                        5
parameters               5
loglik              170.73
AIC                -4.6685
HQ                 -4.6051
SC                 -4.5092

coefficients and diagnostic p-values in Final GUM and terminal model(s)
                 Final GUM
DLEXP_1            0.50074
DLEXP_4           -0.24528
DLEXP_7           0.081445
```

```
DLEXP_8           -0.25484
Constant         0.0071182
k                        5
parameters               5
loglik              170.73
sigma             0.022661
AR(5)              0.87381
ARCH(4)            0.07050
Normality          0.00008
Hetero             0.01922
Chow(70%)          0.99592

p-values of diagnostic checks for model validity
          Initial GUM     cut-off   Final GUM     cut-off Final model
AR(5)         0.84432     0.01000     0.87381     0.01000     0.87381
ARCH(4)       0.04829     0.01000     0.07050     0.01000     0.07050
Normality     0.00008     0.00000     0.00008     0.00000     0.00008
Hetero        0.14779     0.01000     0.01922     0.01000     0.01922
Chow(70%)     0.99731     0.01000     0.99592     0.01000     0.99592

*** Warning: Final model failed 1 diagnostic test(s)

The final model has 4 insignificant coefficients:
Joint significance  LRF( 4) [0.0368]
DLEXP_4             Failed diagnostic testing
DLEXP_7             Failed diagnostic testing
DLEXP_8             Failed diagnostic testing
Constant            Failed diagnostic testing

Summary of Autometrics search
initial search space      2^9  final search space        2^5
no. estimated models       58  no. terminal models         0
test form                LR-F  target size        Small:0.01
large residuals            no  presearch reduction      lags
backtesting              GUM0  tie-breaker                SC
diagnostics p-value      0.01  search effort        standard
time                     0.08  Autometrics version       2.0

EQ( 4) Modelling DLEXP by OLS
       The estimation sample is: 2002(2) - 2019(4)

                  Coefficient  Std.Error  t-value  t-prob Part.R^2
DLEXP_1              0.500738     0.1023     4.90  0.0000   0.2664
DLEXP_4             -0.245283     0.1029    -2.38  0.0200   0.0793
DLEXP_7             0.0814448     0.1138    0.715  0.4769   0.0077
DLEXP_8             -0.254844     0.1144    -2.23  0.0293   0.0700
Constant           0.00711821   0.003082     2.31  0.0240   0.0748

sigma               0.0226611  RSS            0.0338926642
R^2                  0.343549  F(4,66) =     8.635 [0.000]**
Adj.R^2              0.303764  log-likelihood       170.732
no. of observations        71  no. of parameters          5
mean(DLEXP)        0.00768547  se(DLEXP)          0.0271583

AR 1-5 test:      F(5,61)   =  0.36004 [0.8738]
ARCH 1-4 test:    F(4,63)   =   2.2797 [0.0705]
Normality test:   Chi^2(2)  =   18.949 [0.0001]**
Hetero test:      F(8,62)   =   2.5217 [0.0192]*
Hetero-X test:    F(14,56)  =   5.3087 [0.0000]**
RESET23 test:     F(2,64)   =   2.6238 [0.0803]
```

The tool starts from the initially declared specification (8 total lags) and then plays with the lags so as to obtain a better specification. As we can see here, **the tool has removed few of the lags**, leaving only the 1st, 4th, 7th,8th and a constant in the model. However, there has been no improvement

in terms of fit or log-likelihood. The tests outcome is a step backwards, if compared to our best model.
If we look at the graphical representation of this model:

We can see that the fit is not perfect and perhaps we should try to enable the outlier and break detection tool. So, we do this, using still 8 lags:

```
---------- Autometrics: dimensions of initial GUM ----------
no. of observations         71  no. of parameters          9
no. free regressors (k1)     9  no. free components (k2)   0
no. of equations             1  no. diagnostic tests       5

[0.1] Detection of large residuals at 0.005: 1 dummy variables added to the GUM
I:2009(1)       size=4.17493 [0.0000]


---------- Autometrics: dimensions of initial GUM ----------
no. of observations         71  no. of parameters         10
no. free regressors (k1)    10  no. free components (k2)   0
no. of equations             1  no. diagnostic tests       5

[0.2] Presearch reduction of initial GUM

Starting closed lag reduction at 0.11413
Removing lags(#regressors): none

Starting common lag reduction at 0.11413
Removing lags(#regressors): 3-3(1) 6-6(1) 2-2(1) 7-7(1) 5-5(1)

Starting common lag reduction at 0.11413 (excluding lagged y's)
Removing lags(#regressors): none

Presearch reduction in opposite order

Starting common lag reduction at 0.11413 (excluding lagged y's)
Removing lags(#regressors): none

Starting common lag reduction at 0.11413
Removing lags(#regressors): 3-3(1) 6-6(1) 2-2(1) 7-7(1) 5-5(1)

Starting closed lag reduction at 0.11413
Removing lags(#regressors): none

Encompassing test against initial GUM (iGUM) removes: none

Presearch reduction: 5 removed,  LRF_iGUM( 5) [0.7513]
Presearch removed: DLEXP_2 DLEXP_3 DLEXP_5 DLEXP_6 DLEXP_7

[0.3] Testing GUM 0:  LRF( 5) [0.0000] kept
```

```
[1.0] Start of Autometrics tree search

Searching from GUM 0  k=   5 loglik=     185.485
Found new terminal 1  k=   4 loglik=     182.973 SC=   -4.9140

Searching for contrasting terminals in terminal paths

Encompassing test against GUM 0 removes: none

p-values in GUM 1 and saved terminal candidate model(s)
                     GUM 1  terminal 1
DLEXP_1         0.00681202  0.00681202
DLEXP_8         0.00751928  0.00751928
Constant        0.00047731  0.00047731
I:2009(1)       0.00000010  0.00000010
k                        4           4
parameters               4           4
loglik              182.97      182.97
AIC                -5.0415     -5.0415
HQ                 -4.9908     -4.9908
SC                 -4.9140     -4.9140

Searching from GUM 1  k=   4 loglik=     182.973 LRF_GUM0( 1) [0.0313]
Recalling terminal 1  k=   4 loglik=     182.973 SC=   -4.9140

Searching for contrasting terminals in terminal paths

[2.0] Selection of final model from terminal candidates: terminal 1

p-values in Final GUM and terminal model(s)
                 Final GUM  terminal 1
DLEXP_1         0.00681202  0.00681202
DLEXP_8         0.00751928  0.00751928
Constant        0.00047731  0.00047731
I:2009(1)       0.00000010  0.00000010
k                        4           4
parameters               4           4
loglik              182.97      182.97
AIC                -5.0415     -5.0415
HQ                 -4.9908     -4.9908
SC                 -4.9140     -4.9140
                               =======

coefficients and diagnostic p-values in Final GUM and terminal model(s)
                 Final GUM  terminal 1
DLEXP_1            0.25664     0.25664
DLEXP_8           -0.22570    -0.22570
Constant         0.0093424   0.0093424
I:2009(1)         -0.12424    -0.12424
k                        4           4
parameters               4           4
loglik              182.97      182.97
sigma             0.018929    0.018929
AR(5)              0.19564     0.19564
ARCH(4)            0.90047     0.90047
Normality          0.01145     0.01145
Hetero             0.15873     0.15873
Chow(70%)          0.96753     0.96753
                               =======

p-values of diagnostic checks for model validity
          Initial GUM     cut-off   Final GUM     cut-off Final model
AR(5)         0.50709     0.01000     0.19564     0.01000     0.19564
ARCH(4)       0.64845     0.01000     0.90047     0.01000     0.90047
Normality     0.00687     0.00100     0.01145     0.01000     0.01145
Hetero        0.51653     0.01000     0.15873     0.01000     0.15873
```

```
Chow(70%)     0.98353     0.01000     0.96753     0.01000     0.96753
```

```
Summary of Autometrics search
initial search space     2^10  final search space       2^4
no. estimated models       17  no. terminal models        1
test form                LR-F  target size        Small:0.01
large residuals         0.005  presearch reduction      lags
backtesting              GUM0  tie-breaker                SC
diagnostics p-value      0.01  search effort        standard
time                     0.22  Autometrics version       2.0
```

```
EQ( 6) Modelling DLEXP by OLS
       The estimation sample is: 2002(2) - 2019(4)

                  Coefficient  Std.Error  t-value  t-prob Part.R^2
DLEXP_1              0.256641    0.09191     2.79  0.0068   0.1042
DLEXP_8             -0.225698    0.08188    -2.76  0.0075   0.1019
Constant           0.00934245   0.002543     3.67  0.0005   0.1676
I:2009(1)           -0.124241    0.02077    -5.98  0.0000   0.3482

sigma               0.0189295  RSS             0.0240077143
R^2                  0.535006  F(3,67) =      25.7 [0.000]**
Adj.R^2              0.514186  log-likelihood        182.973
no. of observations        71  no. of parameters           4
mean(DLEXP)        0.00768547  se(DLEXP)           0.0271583

AR 1-5 test:      F(5,62)   =   1.5232 [0.1956]
ARCH 1-4 test:    F(4,63)   =  0.26323 [0.9005]
Normality test:   Chi^2(2)  =   8.9399 [0.0114]*
Hetero test:      F(4,65)   =   1.7089 [0.1587]
Hetero-X test:    F(5,64)   =   3.3297 [0.0098]**
RESET23 test:     F(2,65)   =   1.0975 [0.3398]
```

We can see that **only one outlier has been detected by the tool, in <u>2009(1)</u>**, which is surely related to the global crisis. The Automatic model selection has created a created a model where only the 1st and the 8th lag are left, together with a Constant and the dummy variable created to cover for the outlier. So, we are talking of almost the same model created manually, which had resulted to be the best model so far (EQ(52)), with the only difference that here we have no dummy variable covering for 2008(4). Here, R^2 **has increased as well as log-likelihood, and the <u>tests now show only non-normal and heteroscedastic residuals as anomalies</u>**. This model is still worse than EQ(52). We could try to run again the outlier and break detection tool on the model that we have just created. If we do so, here is the result:

```
GUM( 7) Modelling DLEXP by OLS
        The estimation sample is: 2002(2) - 2019(4)

                  Coefficient  Std.Error  t-value  t-prob Part.R^2
DLEXP_1              0.256641    0.09191     2.79  0.0068   0.1042
DLEXP_8             -0.225698    0.08188    -2.76  0.0075   0.1019
Constant           0.00934245   0.002543     3.67  0.0005   0.1676
I:2009(1)           -0.124241    0.02077    -5.98  0.0000   0.3482

sigma               0.0189295  RSS             0.0240077143
R^2                  0.535006  F(3,67) =      25.7 [0.000]**
Adj.R^2              0.514186  log-likelihood        182.973
no. of observations        71  no. of parameters           4
mean(DLEXP)        0.00768547  se(DLEXP)           0.0271583
I:2008(4) [2000(1) - 2019(4)] saved to ITA.xls

AR 1-5 test:      F(5,62)   =   1.5232 [0.1956]
ARCH 1-4 test:    F(4,63)   =  0.26323 [0.9005]
Normality test:   Chi^2(2)  =   8.9399 [0.0114]*
```

```
Hetero test:      F(4,65)   =   1.7089 [0.1587]
Chow test:        F(20,47)  =  0.46513 [0.9675]   for break after 2014(4)


---------- Autometrics: dimensions of initial GUM ----------
no. of observations        71  no. of parameters           4
no. free regressors (k1)    4  no. free components (k2)    0
no. of equations            1  no. diagnostic tests        5

[0.1] Detection of large residuals at 0.005: 1 dummy variables added to the GUM
I:2008(4)       size=3.69053 [0.0002]


---------- Autometrics: dimensions of initial GUM ----------
no. of observations        71  no. of parameters           5
no. free regressors (k1)    5  no. free components (k2)    0
no. of equations            1  no. diagnostic tests        5

[0.2] Presearch reduction of initial GUM

Starting closed lag reduction at 0.11413
Removing lags(#regressors): none

Starting common lag reduction at 0.11413
Removing lags(#regressors): none

Starting common lag reduction at 0.11413 (excluding lagged y's)
Removing lags(#regressors): none

Presearch reduction in opposite order

Starting common lag reduction at 0.11413 (excluding lagged y's)
Removing lags(#regressors): none

Starting common lag reduction at 0.11413
Removing lags(#regressors): none

Starting closed lag reduction at 0.11413
Removing lags(#regressors): none

Encompassing test against initial GUM (iGUM) removes: none

Presearch reduction: none removed

[0.3] Testing GUM 0:  LRF( 5) [0.0000] kept

[1.0] Start of Autometrics tree search

Searching from GUM 0  k=   5 loglik=     191.726
Found new terminal 1  k=   4 loglik=     188.953 SC=   -5.0825
Found new terminal 2  k=   4 loglik=     188.450 SC=   -5.0683

Searching for contrasting terminals in terminal paths

[2.0] Selection of final model from terminal candidates: terminal 1

p-values in Final GUM and terminal model(s)
                 Final GUM  terminal 1  terminal 2
DLEXP_1         0.01394411  0.00593069           .
DLEXP_8         0.02369597           .  0.01003548
Constant        0.00002288  0.00021116  0.00000025
I:2009(1)       0.00000000  0.00000001  0.00000000
I:2008(4)       0.00005843  0.00001839  0.00002749
k                        5           4           4
parameters               5           4           4
loglik              191.73      188.95      188.45
AIC                -5.2599     -5.2100     -5.1958
```

```
HQ                  -5.1965     -5.1593     -5.1451
SC                  -5.1006     -5.0825     -5.0683
                                =======

coefficients and diagnostic p-values in Final GUM and terminal model(s)
                 Final GUM  terminal 1  terminal 2
DLEXP_1            0.20869     0.23924           .
DLEXP_8           -0.17139           .    -0.20124
Constant          0.010386   0.0087762    0.012579
I:2009(1)         -0.12918    -0.12542    -0.14790
I:2008(4)        -0.075094   -0.082008   -0.081060
k                        5           4           4
parameters               5           4           4
loglik              191.73      188.95      188.45
sigma             0.016860    0.017400    0.017524
AR(5)              0.24808     0.10786     0.27228
ARCH(4)            0.68905     0.63627     0.55804
Normality          0.50494     0.52812     0.19283
Hetero             0.89190     0.94529     0.64053
Chow(70%)          0.87471     0.86112     0.94797
                                =======

p-values of diagnostic checks for model validity
          Initial GUM     cut-off   Final GUM     cut-off Final model
AR(5)         0.24808     0.01000     0.24808     0.01000     0.10786
ARCH(4)       0.68905     0.01000     0.68905     0.01000     0.63627
Normality     0.50494     0.01000     0.50494     0.01000     0.52812
Hetero        0.89190     0.01000     0.89190     0.01000     0.94529
Chow(70%)     0.87471     0.01000     0.87471     0.01000     0.86112


Summary of Autometrics search
initial search space      2^5  final search space        2^5
no. estimated models        9  no. terminal models         2
test form                LR-F  target size        Small:0.01
large residuals         0.005  presearch reduction      lags
backtesting              GUM0  tie-breaker                SC
diagnostics p-value      0.01  search effort        standard
time                     0.06  Autometrics version       2.0

EQ( 8) Modelling DLEXP by OLS
       The estimation sample is: 2002(2) - 2019(4)

                  Coefficient  Std.Error  t-value  t-prob Part.R^2
DLEXP_1              0.239236    0.08417     2.84  0.0059   0.1076
Constant           0.00877616   0.002239     3.92  0.0002   0.1865
I:2009(1)           -0.125416    0.01905    -6.58  0.0000   0.3927
I:2008(4)          -0.0820079    0.01778    -4.61  0.0000   0.2411

sigma               0.0174004  RSS            0.0202859089
R^2                  0.607092  F(3,67) =     34.51 [0.000]**
Adj.R^2              0.589499  log-likelihood        188.953
no. of observations        71  no. of parameters           4
mean(DLEXP)        0.00768547  se(DLEXP)           0.0271583

AR 1-5 test:      F(5,62)   =   1.8960 [0.1079]
ARCH 1-4 test:    F(4,63)   =  0.63951 [0.6363]
Normality test:   Chi^2(2)  =   1.2768 [0.5281]
Hetero test:      F(2,66)   = 0.056316 [0.9453]
Hetero-X test:    F(2,66)   = 0.056316 [0.9453]
RESET23 test:     F(2,65)   =  0.82576 [0.4424]
```

Surprisingly, the tool has added **another dummy variable**, which accounts for 2008(4). All the parameters of this model are strongly significant, however, we can see that the 8th lag has been removed. R^2 **has furtherly improved, as well as log-likelihood did**. **The tests are all showing**

good information, finally. There is no autocorrelation within 5 lags, no ARCH effect, the residuals are normal and homoscedastic, and the linear form is proper for this model. **We have obtained a model which is very similar to EQ(52)**; perhaps, **this one is more accurate**, as now all parameters are statistically significant. The decrease of R^2 and log-likelihood compared to those of EQ(52) is negligible. Here is the graphical representation of the model:

As we can see, **now the 2009's outlier is perfectly taken into account by the model**. **This, added to the significance of all parameters and the positivity of diagnostics indicates this model as the best one for DLEXP.**

Now, we can move to DLIMP series. After seeing the ACF graph for the series, we will create a first model with 5 lags, since we had seen in the beginning of this paper that there is autocorrelation up to the 5th lag in DLIMP:

```
EQ( 9) Modelling DLIMP by OLS
       The estimation sample is: 2001(3) - 2019(4)

                  Coefficient  Std.Error  t-value  t-prob Part.R^2
DLIMP_1              0.490570     0.1172     4.19  0.0001   0.2048
DLIMP_2            -0.0287728     0.1247   -0.231  0.8182   0.0008
DLIMP_3             0.0503225     0.1249    0.403  0.6882   0.0024
DLIMP_4             -0.178968     0.1274    -1.40  0.1646   0.0282
DLIMP_5             -0.117140     0.1158    -1.01  0.3152   0.0148
Constant           0.00488611   0.003351     1.46  0.1494   0.0303

sigma               0.0269772  RSS            0.0494882248
R^2                  0.316864  F(5,68) =      6.308 [0.000]**
Adj.R^2              0.266633  log-likelihood        165.472
no. of observations        74  no. of parameters           6
mean(DLIMP)        0.00592822  se(DLIMP)           0.0315018

AR 1-5 test:      F(5,63)   =   1.9163 [0.1041]
ARCH 1-4 test:    F(4,66)   =   2.5221 [0.0492]*
Normality test:   Chi^2(2)  =   14.523 [0.0007]**
Hetero test:      F(10,63)  =  0.67853 [0.7401]
Hetero-X test:    F(20,53)  =   1.5985 [0.0883]
RESET23 test:     F(2,66)   =  0.55453 [0.5770]
```

So, we can see that among these lags, **only the 1st lag is significant**. There is **no autocorrelation, the residuals are homoscedastic and the linear form seems proper**; however, there is a very **light ARCH effect and the residuals are non-normal**.
We could try to reformulate the model, but using just 1 lag this time:

```
EQ(10) Modelling DLIMP by OLS
```

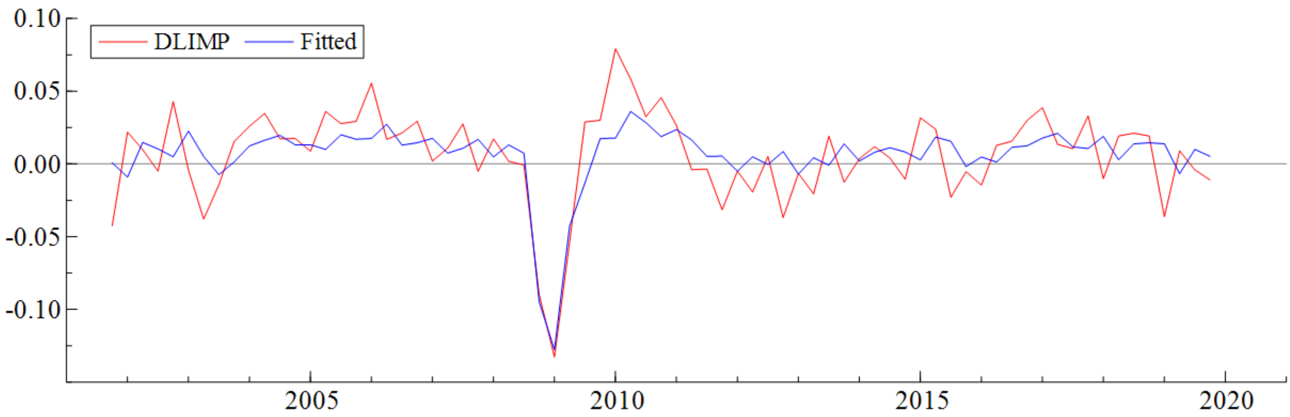
```
       The estimation sample is: 2000(3) - 2019(4)

                  Coefficient  Std.Error  t-value  t-prob Part.R^2
DLIMP_1              0.476470    0.09983     4.77  0.0000   0.2306
Constant           0.00314300   0.003268    0.962  0.3393   0.0120

sigma                0.0281145  RSS              0.0600724849
R^2                   0.230601  F(1,76) =      22.78 [0.000]**
Adj.R^2               0.220477  log-likelihood         168.91
no. of observations         78  no. of parameters           2
mean(DLIMP)         0.00667374  se(DLIMP)           0.0318432

AR 1-5 test:      F(5,71)   =   1.5458 [0.1867]
ARCH 1-4 test:    F(4,70)   =   2.1441 [0.0844]
Normality test:   Chi^2(2)  =   8.9665 [0.0113]*
Hetero test:      F(2,75)   =   3.0305 [0.0542]
Hetero-X test:    F(2,75)   =   3.0305 [0.0542]
RESET23 test:     F(2,74)   =  0.50763 [0.6040]
```

This seems to be a better model, in the sense that **ARCH effect has been totally removed** and log-**likelihood has increased**; however, R^2 **is very low now** (0.230601) and the **residuals are still non-normal**.

It could be a good idea to act as we did for DLEXP series; namely we will create another specification with just the 1st lag, a Constant and the dummy variable accounting for the 2008(4)-2009(1) period:

```
EQ(55) Modelling DLIMP by OLS
       The estimation sample is: 2001(4) - 2019(4)

                  Coefficient  Std.Error  t-value  t-prob Part.R^2
DLIMP_1              0.370865    0.08584     4.32  0.0001   0.2105
Constant           0.00671359   0.002711     2.48  0.0157   0.0805
dummy1+2            -0.101169    0.01653    -6.12  0.0000   0.3485

sigma                0.0221732  RSS              0.0344156032
R^2                   0.521759  F(2,70) =      38.18 [0.000]**
Adj.R^2               0.508095  log-likelihood        175.997
no. of observations         73  no. of parameters           3
mean(DLIMP)         0.00622627  se(DLIMP)           0.0316146

AR 1-5 test:      F(5,65)   =   1.3539 [0.2533]
ARCH 1-4 test:    F(4,65)   =  0.64996 [0.6290]
Normality test:   Chi^2(2)  =  0.79300 [0.6727]
Hetero test:      F(3,69)   =  0.37255 [0.7731]
Hetero-X test:    F(3,69)   =  0.37255 [0.7731]
RESET23 test:     F(2,68)   =  0.25397 [0.7764]
```

This was a good move, as now **all parameters are statistically significant**, **both R^2 and log-likelihood have strongly improved** and the **results from the diagnostics are all positive**, so there is no autocorrelation within 5 lags, no ARCH effect, the residuals are normal and homoscedastic and the linear form is proper in this specification. Let's check the graphical representation for the model:



Now, the 2009's outlier is taken into account; the overall fit is not the best

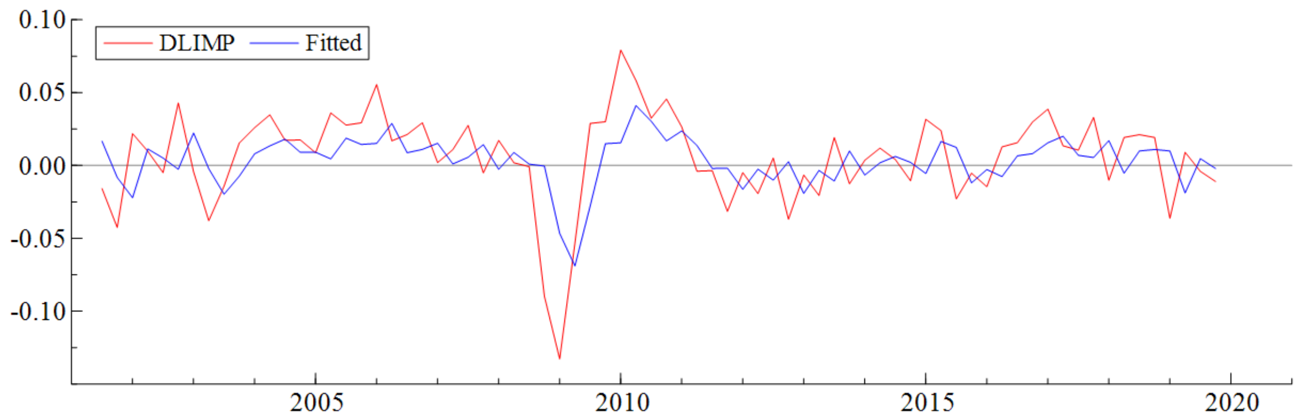
Now, we can try to see what an Automatic model selection can do, reinserting the initial 5 lags so as to give the tool more "maneuvre opportunities":

```
GUM(13) Modelling DLIMP by OLS
        The estimation sample is: 2001(3) - 2019(4)

                  Coefficient  Std.Error  t-value  t-prob Part.R^2
DLIMP_1              0.490570     0.1172     4.19  0.0001   0.2048
DLIMP_2            -0.0287728     0.1247   -0.231  0.8182   0.0008
DLIMP_3             0.0503225     0.1249    0.403  0.6882   0.0024
DLIMP_4             -0.178968     0.1274    -1.40  0.1646   0.0282
DLIMP_5             -0.117140     0.1158    -1.01  0.3152   0.0148
Constant           0.00488611   0.003351     1.46  0.1494   0.0303

sigma               0.0269772  RSS              0.0494882248
R^2                  0.316864  F(5,68) =      6.308 [0.000]**
Adj.R^2              0.266633  log-likelihood        165.472
no. of observations        74  no. of parameters           6
mean(DLIMP)        0.00592822  se(DLIMP)           0.0315018

AR 1-5 test:      F(5,63)    =   1.9163 [0.1041]
ARCH 1-4 test:    F(4,66)    =   2.5221 [0.0492]*
Normality test:   Chi^2(2)   =   14.523 [0.0007]**
Hetero test:      F(10,63)   =  0.67853 [0.7401]
Chow test:        F(21,47)   =  0.54353 [0.9348]   for break after 2014(3)


---------- Autometrics: dimensions of initial GUM ----------
no. of observations        74  no. of parameters           6
no. free regressors (k1)    6  no. free components (k2)    0
no. of equations            1  no. diagnostic tests        5

[0.2] Presearch reduction of initial GUM

Starting closed lag reduction at 0.11413
Removing lags(#regressors): 5-5(1)
```

```
Starting common lag reduction at 0.11413
Removing lags(#regressors): 2-2(1) 3-3(1)

Starting common lag reduction at 0.11413 (excluding lagged y's)
Removing lags(#regressors): none

Presearch reduction in opposite order

Starting common lag reduction at 0.11413 (excluding lagged y's)
Removing lags(#regressors): none

Starting common lag reduction at 0.11413
Removing lags(#regressors): 2-2(1) 3-3(1) 5-5(1)

Starting closed lag reduction at 0.11413
Removing lags(#regressors): none

Encompassing test against initial GUM (iGUM) removes: none

Presearch reduction: 3 removed,  LRF_iGUM( 3) [0.7415]
Presearch removed: DLIMP_2 DLIMP_3 DLIMP_5

[0.3] Testing GUM 0:  LRF( 3) [0.0000] kept

[1.0] Start of Autometrics tree search

Searching from GUM 0  k=   3 loglik=     164.798
Found new terminal 1  k=   1 loglik=     161.866 SC=   -4.3166

Searching for contrasting terminals in terminal paths

Encompassing test against GUM 0 removes: none

[2.0] Selection of final model from terminal candidates: terminal 1

p-values in Final GUM and terminal model(s)
                 Final GUM  terminal 1
DLIMP_1         0.00000152  0.00000152
k                        1           1
parameters               1           1
loglik              161.87      161.87
AIC                -4.3477     -4.3477
HQ                 -4.3353     -4.3353
SC                 -4.3166     -4.3166
                               =======

coefficients and diagnostic p-values in Final GUM and terminal model(s)
                 Final GUM  terminal 1
DLIMP_1            0.51939     0.51939
k                        1           1
parameters               1           1
loglik              161.87      161.87
sigma             0.027337    0.027337
AR(5)              0.38574     0.38574
ARCH(4)            0.19676     0.19676
Normality          0.01088     0.01088
Hetero             0.04108     0.04108
Chow(70%)          0.92568     0.92568
                               =======

p-values of diagnostic checks for model validity
          Initial GUM     cut-off   Final GUM     cut-off Final model
AR(5)         0.10409     0.01000     0.38574     0.01000     0.38574
ARCH(4)       0.04919     0.01000     0.19676     0.01000     0.19676
Normality     0.00070     0.00010     0.01088     0.00010     0.01088
Hetero        0.74011     0.01000     0.04108     0.01000     0.04108
Chow(70%)     0.93475     0.01000     0.92568     0.01000     0.92568
```

```
Summary of Autometrics search
initial search space      2^6  final search space        2^1
no. estimated models       12  no. terminal models         1
test form                LR-F  target size        Small:0.01
large residuals            no  presearch reduction      lags
backtesting              GUM0  tie-breaker                SC
diagnostics p-value      0.01  search effort        standard
time                     0.09  Autometrics version       2.0

EQ(14) Modelling DLIMP by OLS
       The estimation sample is: 2001(3) - 2019(4)

                 Coefficient  Std.Error  t-value  t-prob Part.R^2
DLIMP_1             0.519389    0.09919     5.24  0.0000   0.2730

sigma              0.0273369  RSS               0.054553453
log-likelihood       161.866
no. of observations       74  no. of parameters           1
mean(DLIMP)       0.00592822  se(DLIMP)           0.0315018

AR 1-5 test:      F(5,68)    =   1.0682 [0.3857]
ARCH 1-4 test:    F(4,66)    =   1.5548 [0.1968]
Normality test:   Chi^2(2)   =   9.0408 [0.0109]*
Hetero test:      F(2,71)    =   3.3402 [0.0411]*
Hetero-X test:    F(2,71)    =   3.3402 [0.0411]*
RESET23 test:     F(2,71)    =  0.23701 [0.7896]
```

As we can see, **the situation is just worse here**. Only the 1st lag is kept, which was predictable after seeing the previous models. The **log-likelihood is lower now and there is heteroscedasticity together with non-normality**. And if we look at the graphical representation for this model:



We can deduce that we should try to cover the 2009 outlier, using the outlier and break detection this time:

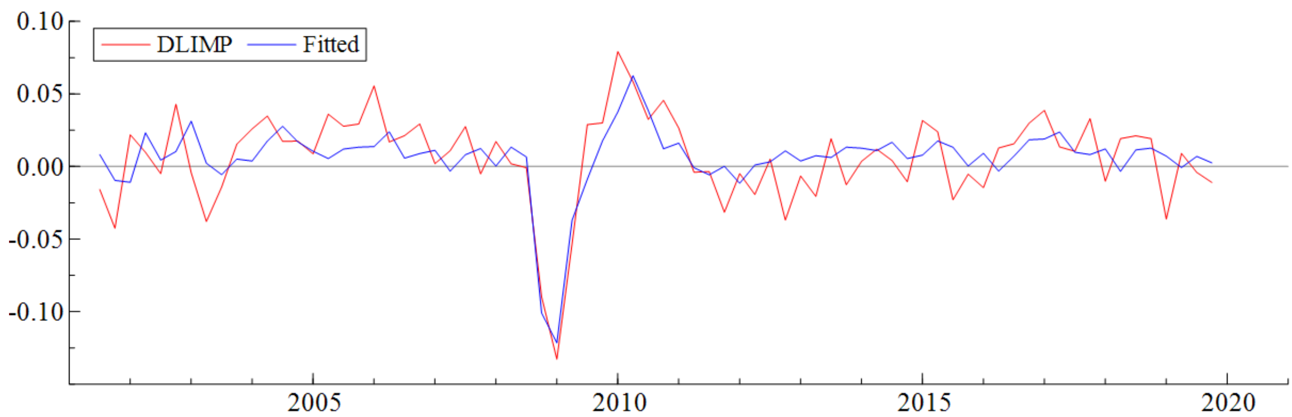
```
GUM(17) Modelling DLIMP by OLS
        The estimation sample is: 2001(3) - 2019(4)

                 Coefficient  Std.Error  t-value  t-prob Part.R^2
DLIMP_1             0.490570     0.1172     4.19  0.0001   0.2048
DLIMP_2           -0.0287728     0.1247   -0.231  0.8182   0.0008
DLIMP_3            0.0503225     0.1249    0.403  0.6882   0.0024
DLIMP_4            -0.178968     0.1274    -1.40  0.1646   0.0282
DLIMP_5            -0.117140     0.1158    -1.01  0.3152   0.0148
Constant          0.00488611   0.003351     1.46  0.1494   0.0303

sigma              0.0269772  RSS              0.0494882248
```

```
R^2                  0.316864  F(5,68) =     6.308 [0.000]**
Adj.R^2              0.266633  log-likelihood        165.472
no. of observations        74  no. of parameters           6
mean(DLIMP)        0.00592822  se(DLIMP)           0.0315018

AR 1-5 test:      F(5,63)   =   1.9163 [0.1041]
ARCH 1-4 test:    F(4,66)   =   2.5221 [0.0492]*
Normality test:   Chi^2(2)  =   14.523 [0.0007]**
Hetero test:      F(10,63)  =  0.67853 [0.7401]
Chow test:        F(21,47)  =  0.54353 [0.9348]   for break after 2014(3)


---------- Autometrics: dimensions of initial GUM ----------
no. of observations        74  no. of parameters           6
no. free regressors (k1)    6  no. free components (k2)    0
no. of equations            1  no. diagnostic tests        5

[0.1] Detection of large residuals at 0.005: 2 dummy variables added to the GUM
I:2008(4)       size=3.43654 [0.0006]
I:2009(1)+I:2008(4) size=3.38254 [0.0007]


---------- Autometrics: dimensions of initial GUM ----------
no. of observations        74  no. of parameters           8
no. free regressors (k1)    8  no. free components (k2)    0
no. of equations            1  no. diagnostic tests        5

[0.2] Presearch reduction of initial GUM

Starting closed lag reduction at 0.11413
Removing lags(#regressors): none

Starting common lag reduction at 0.11413
Removing lags(#regressors): 2-2(1) 3-3(1)

Starting common lag reduction at 0.11413 (excluding lagged y's)
Removing lags(#regressors): none

Presearch reduction in opposite order

Starting common lag reduction at 0.11413 (excluding lagged y's)
Removing lags(#regressors): none

Starting common lag reduction at 0.11413
Removing lags(#regressors): 2-2(1) 3-3(1)

Starting closed lag reduction at 0.11413
Removing lags(#regressors): none

Encompassing test against initial GUM (iGUM) removes: none

Presearch reduction: 2 removed,  LRF_iGUM( 2) [0.5714]
Presearch removed: DLIMP_2 DLIMP_3

[0.3] Testing GUM 0:  LRF( 6) [0.0000] kept

[1.0] Start of Autometrics tree search

Searching from GUM 0  k=   6 loglik=     183.158
Found new terminal 1  k=   4 loglik=     181.661 SC=   -4.6771
Found new terminal 2  k=   4 loglik=     181.642 SC=   -4.6766

Searching for contrasting terminals in terminal paths

Encompassing test against GUM 0 removes: none

p-values in GUM 1 and saved terminal candidate model(s)
```

```
                         GUM 1  terminal 1  terminal 2
DLIMP_1             0.00016470  0.00037155  0.00003102
DLIMP_4             0.11396117           .  0.00639868
DLIMP_5             0.11136599  0.00626902           .
Constant            0.00169228  0.00266185  0.00397678
I:2009(1)+I:2008(4)  0.00000001  0.00000001  0.00000002
k                            5           4           4
parameters                   5           4           4
loglik                  183.01      181.66      181.64
AIC                    -4.8111     -4.8017     -4.8011
HQ                     -4.7490     -4.7520     -4.7514
SC                     -4.6554     -4.6771     -4.6766

Searching from GUM 1  k=   5 loglik=     183.011 LRF_GUM0( 1) [0.6043]
Recalling terminal 1  k=   4 loglik=     181.661 SC=   -4.6771
Recalling terminal 2  k=   4 loglik=     181.642 SC=   -4.6766

Searching for contrasting terminals in terminal paths

[2.0] Selection of final model from terminal candidates: terminal 1

p-values in Final GUM and terminal model(s)
                     Final GUM  terminal 1  terminal 2
DLIMP_1             0.00016470  0.00037155  0.00003102
DLIMP_4             0.11396117           .  0.00639868
DLIMP_5             0.11136599  0.00626902           .
Constant            0.00169228  0.00266185  0.00397678
I:2009(1)+I:2008(4)  0.00000001  0.00000001  0.00000002
k                            5           4           4
parameters                   5           4           4
loglik                  183.01      181.66      181.64
AIC                    -4.8111     -4.8017     -4.8011
HQ                     -4.7490     -4.7520     -4.7514
SC                     -4.6554     -4.6771     -4.6766
                                   =======

coefficients and diagnostic p-values in Final GUM and terminal model(s)
                     Final GUM  terminal 1  terminal 2
DLIMP_1                0.33467     0.31374     0.36724
DLIMP_4               -0.14367           .    -0.21845
DLIMP_5               -0.14600    -0.22088           .
Constant             0.0087719   0.0084297   0.0079342
I:2009(1)+I:2008(4)    -0.10234    -0.10298    -0.10122
k                            5           4           4
parameters                   5           4           4
loglik                  183.01      181.66      181.64
sigma                 0.021130    0.021364    0.021370
AR(5)                  0.57329     0.76536     0.14965
ARCH(4)                0.55978     0.60312     0.53497
Normality              0.41569     0.70733     0.21498
Hetero                 0.59644     0.92922     0.51668
Chow(70%)              0.63076     0.74588     0.53188
                                   =======

p-values of diagnostic checks for model validity
          Initial GUM     cut-off   Final GUM     cut-off Final model
AR(5)         0.27693     0.01000     0.57329     0.01000     0.76536
ARCH(4)       0.66193     0.01000     0.55978     0.01000     0.60312
Normality     0.50823     0.01000     0.41569     0.01000     0.70733
Hetero        0.05507     0.01000     0.59644     0.01000     0.92922
Chow(70%)     0.68661     0.01000     0.63076     0.01000     0.74588


Summary of Autometrics search
initial search space      2^8  final search space        2^5
no. estimated models       20  no. terminal models         2
test form                LR-F  target size        Small:0.01
```

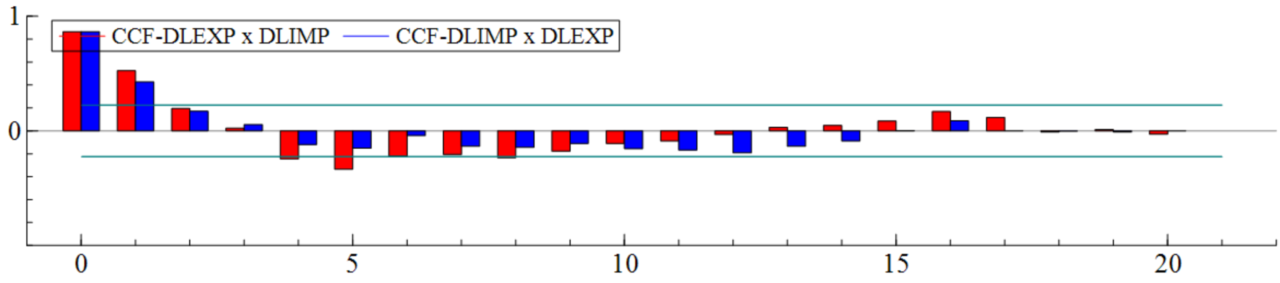
```
large residuals          0.005  presearch reduction      lags
backtesting               GUM0  tie-breaker                SC
diagnostics p-value       0.01  search effort        standard
time                      0.10  Autometrics version       2.0

EQ(18) Modelling DLIMP by OLS
       The estimation sample is: 2001(3) - 2019(4)

                       Coefficient  Std.Error  t-value  t-prob Part.R^2
DLIMP_1                   0.313742    0.08386     3.74  0.0004   0.1666
DLIMP_5                  -0.220877    0.07837    -2.82  0.0063   0.1019
Constant                0.00842968   0.002706     3.12  0.0027   0.1218
I:2009(1)+I:2008(4)      -0.102979    0.01594    -6.46  0.0000   0.3735

sigma              0.0213643  RSS              0.0319501877
R^2                 0.558959  F(3,70) =      29.57 [0.000]**
Adj.R^2             0.540057  log-likelihood        181.661
no. of observations       74  no. of parameters           4
mean(DLIMP)       0.00592822  se(DLIMP)           0.0315018

AR 1-5 test:      F(5,65)    =  0.51313 [0.7654]
ARCH 1-4 test:    F(4,66)    =  0.68757 [0.6031]
Normality test:   Chi^2(2)   =  0.69251 [0.7073]
Hetero test:      F(5,68)    =  0.26772 [0.9292]
Hetero-X test:    F(6,67)    =  0.21984 [0.9691]
RESET23 test:     F(2,68)    =  0.42190 [0.6575]
```

As we can see, **two dummy variables have been introduced to cover for 2008(4) and 2009(1)**. These two variables, together with a constant and the 1st and 5th lags, constitute our model. There has been further **improvement in R^2 and in log-likelihood, and the tests' outcome don't show any anomalies**. So, this becomes our best model for DLIMP. Here is the graphical representation:



We can see the improvement in fit, even though it is not perfect.

So far, we have estimated two specifications individually for DExport and DImport. Now, we should join those two so as to get a good model for VAR. But first, we need to look back at our CCF graph drawn initially:

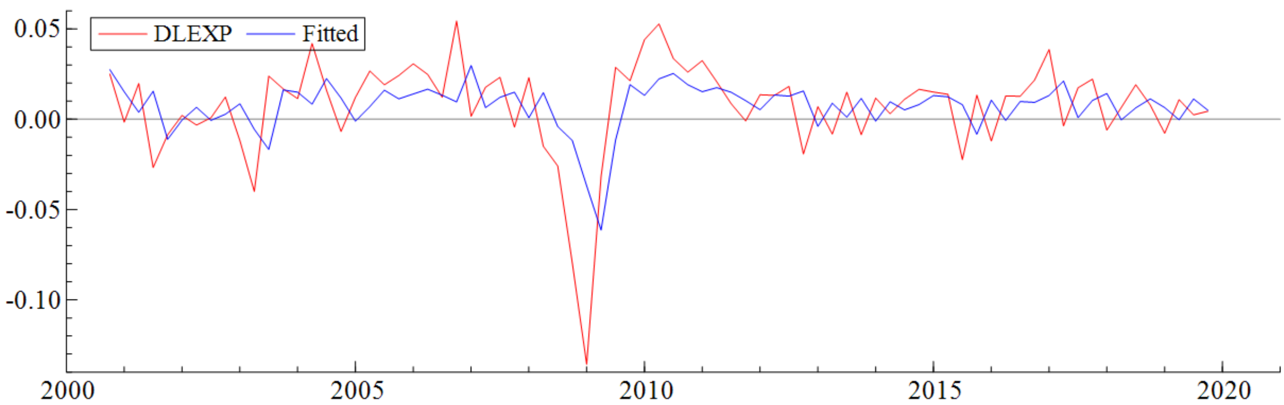


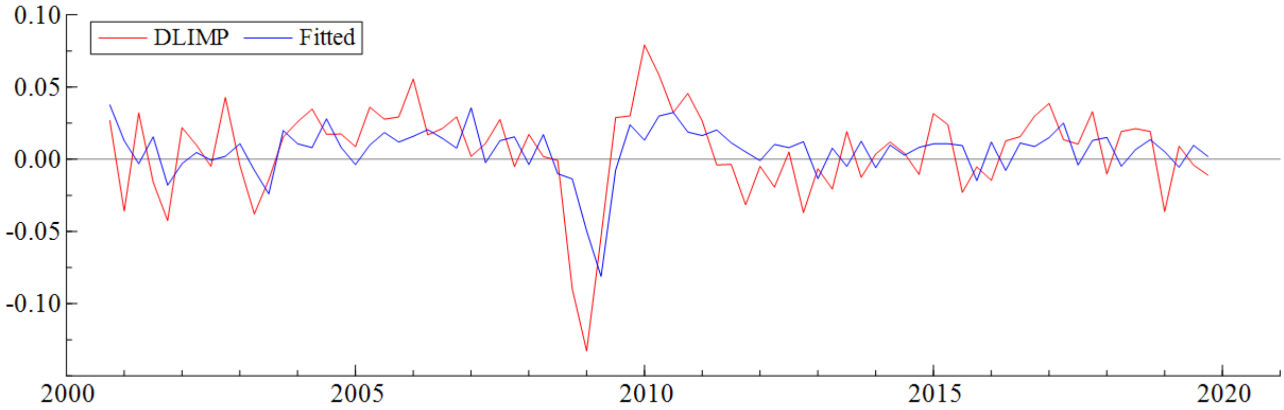
Here there are only 1st and 2nd significant lags for both correlations. We will model using the Multiple-equation Dynamic Modelling using PcGive as a Model class, starting with 2 lags, with unrestricted system as a Model type and OLS as estimation method:

```
SYS(19) Estimating the system by OLS
        The estimation sample is: 2000(4) - 2019(4)

URF equation for: DLEXP
                  Coefficient  Std.Error  t-value  t-prob
DLEXP_1              0.523837     0.2051     2.55  0.0128
DLEXP_2             0.0933208     0.2085    0.448  0.6558
DLIMP_1            -0.0415890     0.1799   -0.231  0.8178
DLIMP_2            -0.0923359     0.1692   -0.546  0.5869
Constant      U    0.00331629   0.002882     1.15  0.2537

sigma = 0.0237352   RSS = 0.04056188915

URF equation for: DLIMP
                  Coefficient  Std.Error  t-value  t-prob
DLEXP_1              0.631975     0.2351     2.69  0.0089
DLEXP_2            -0.0849048     0.2391   -0.355  0.7235
DLIMP_1             0.0347167     0.2062    0.168  0.8668
DLIMP_2           -0.00978179     0.1940  -0.0504  0.9599
Constant      U    0.00152534   0.003305    0.462  0.6458

sigma = 0.0272118   RSS = 0.05331474944

log-likelihood      395.986939  -T/2log|Omega|     614.503473
|Omega|          1.1699564e-07  log|Y'Y/T|        -15.5843301
R^2(LR)               0.313946  R^2(LM)              0.161196
no. of observations         77  no. of parameters          10

F-test on regressors except unrestricted: F(8,142) = 3.67986 [0.0006] **
F-tests on retained regressors, F(2,71) =
     DLEXP_1       3.73894 [0.029]*      DLEXP_2      0.904515 [0.409]
     DLIMP_1      0.224399 [0.800]       DLIMP_2      0.391982 [0.677]
    Constant U     1.01671 [0.367]

correlation of URF residuals (standard deviations on diagonal)
              DLEXP        DLIMP
DLEXP      0.023735      0.82416
DLIMP       0.82416     0.027212
correlation between actual and fitted
        DLEXP        DLIMP
      0.49364      0.54051

Single-equation diagnostics using reduced-form residuals:
DLEXP       : Portmanteau( 9):  Chi^2(7)   =   9.1071 [0.2451]
DLEXP       : AR 1-5 test:      F(5,67)    =   1.2724 [0.2862]
DLEXP       : ARCH 1-4 test:    F(4,69)    =   2.8593 [0.0297]*
DLEXP       : Normality test:   Chi^2(2)   =   16.170 [0.0003]**
DLEXP       : Hetero test:      F(8,68)    =   3.9764 [0.0007]**
DLEXP       : Hetero-X test:    F(14,62)   =   11.307 [0.0000]**
DLIMP       : Portmanteau( 9):  Chi^2(7)   =   8.7165 [0.2737]
```

```
DLIMP       : AR 1-5 test:      F(5,67)   =   2.7084 [0.0274]*
DLIMP       : ARCH 1-4 test:    F(4,69)   =   2.4854 [0.0514]
DLIMP       : Normality test:   Chi^2(2)  =   5.5272 [0.0631]
DLIMP       : Hetero test:      F(8,68)   =   1.5839 [0.1460]
DLIMP       : Hetero-X test:    F(14,62)  =   4.2917 [0.0000]**

Vector Portmanteau( 9):  Chi^2(28) =   40.819 [0.0558]
Vector AR 1-5 test:      F(20,122) =   2.0212 [0.0105]*
Vector Normality test:   Chi^2(4)  =   15.592 [0.0036]**
Vector Hetero test:      F(24,192) =   1.6091 [0.0423]*
Vector Hetero-X test:    F(42,178) =   3.1202 [0.0000]**
Vector RESET23 test:     F(8,134)  =   2.0482 [0.0453]*
```

Many things are to be discussed when creating a multivariate specification. Starting from the single equation for DLEXP, where we can see that **only the 1st lag of DLEXP is significant, which is the same as in the single equation for DLIMP**. The value **of R^2 is not very high**, while log-likelihood equals 395.986.
The F-test on regressors shows which of the chosen particular parameters are significant enough to be considered reasonable for our model. As we can see, **there is a confirmation that only DLEXP_1 has to be used in our model**.
The correlation of residuals is quite high (0.82416); we would rather have a lower one, while the **correlation between actual and fitted is for DLEXP and DLIMP is not very high** (0.49364 and 0.54051 respectively), but we would like this one to be higher.
The diagnostics show terrible results on almost every possible aspect: for DLEXP we have ARCH effect, non-normal and heteroscedastic residuals; for DLIMP we have autocorrelation and heteroscedasticity. For the multivariate approach, in diagnostics we have autocorrelation, non-normal and heteroscedastic residuals, and the linear form is not proper for this model.
Here are the graphical representations for the model:





The models seem to be fitted just roughly. Now, let's try to set even 8 lags. We had a decent output with 8 lags for DLEXP and we can verify if we will obtain that again:

```
SYS(20) Estimating the system by OLS
        The estimation sample is: 2002(2) - 2019(4)

URF equation for: DLEXP
                  Coefficient  Std.Error  t-value  t-prob
DLEXP_1              0.616760     0.2390     2.58  0.0126
DLEXP_2              0.347123     0.2582     1.34  0.1844
DLEXP_3              0.249433     0.2413     1.03  0.3059
DLEXP_4             -0.376613     0.2613    -1.44  0.1553
DLEXP_5             -0.271424     0.2622    -1.04  0.3053
DLEXP_6             -0.441237     0.2399    -1.84  0.0714
DLEXP_7              0.257983     0.2550     1.01  0.3161
DLEXP_8             -0.331897     0.2455    -1.35  0.1820
DLIMP_1             -0.124630     0.2187   -0.570  0.5711
DLIMP_2             -0.427140     0.2183    -1.96  0.0556
DLIMP_3            -0.0380165     0.2218   -0.171  0.8646
DLIMP_4              0.151706     0.2330    0.651  0.5178
DLIMP_5              0.187585     0.2013    0.932  0.3555
DLIMP_6              0.362530     0.1995     1.82  0.0747
DLIMP_7             -0.307776     0.2123    -1.45  0.1529
DLIMP_8              0.209322     0.1851     1.13  0.2632
Constant      U    0.00707873   0.003335     2.12  0.0384

sigma = 0.0226849   RSS = 0.02778869568

URF equation for: DLIMP
                  Coefficient  Std.Error  t-value  t-prob
DLEXP_1              0.805752     0.2565     3.14  0.0027
DLEXP_2              0.248214     0.2771    0.896  0.3744
DLEXP_3             -0.184304     0.2590   -0.712  0.4798
DLEXP_4             -0.684649     0.2805    -2.44  0.0180
DLEXP_5             -0.243659     0.2815   -0.866  0.3905
DLEXP_6             -0.174034     0.2575   -0.676  0.5020
DLEXP_7              0.404981     0.2736     1.48  0.1447
DLEXP_8             -0.284909     0.2635    -1.08  0.2844
DLIMP_1             -0.113010     0.2347   -0.481  0.6321
DLIMP_2             -0.212912     0.2343   -0.909  0.3675
DLIMP_3              0.239829     0.2381     1.01  0.3183
DLIMP_4              0.366318     0.2501     1.46  0.1488
DLIMP_5            -0.0150107     0.2160  -0.0695  0.9449
DLIMP_6              0.225664     0.2141     1.05  0.2966
DLIMP_7             -0.449255     0.2278    -1.97  0.0538
DLIMP_8              0.226454     0.1987     1.14  0.2595
Constant      U    0.00522508   0.003580     1.46  0.1502

sigma = 0.024347   RSS = 0.03201001707

log-likelihood     391.918089  -T/2log|Omega|     593.407361
|Omega|        5.50127805e-08  log|Y'Y/T|        -15.6291531
R^2(LR)              0.662621  R^2(LM)               0.40348
no. of observations        71  no. of parameters          34

F-test on regressors except unrestricted: F(32,106) = 2.39041 [0.0005] **
F-tests on retained regressors, F(2,53) =
     DLEXP_1       4.84353 [0.012]*     DLEXP_2      0.962857 [0.388]
     DLEXP_3       4.39959 [0.017]*     DLEXP_4       3.46047 [0.039]*
     DLEXP_5      0.525802 [0.594]      DLEXP_6       2.79654 [0.070]
     DLEXP_7       1.14834 [0.325]      DLEXP_8      0.899520 [0.413]
     DLIMP_1      0.159504 [0.853]      DLIMP_2       2.68271 [0.078]
     DLIMP_3       2.09412 [0.133]      DLIMP_4       1.55353 [0.221]
     DLIMP_5       1.54410 [0.223]      DLIMP_6       1.94429 [0.153]
     DLIMP_7       1.96265 [0.151]      DLIMP_8      0.691300 [0.505]
    Constant U     2.35297 [0.105]
```

```
correlation of URF residuals (standard deviations on diagonal)
              DLEXP        DLIMP
DLEXP      0.022685      0.82960
DLIMP       0.82960     0.024347
correlation between actual and fitted
        DLEXP        DLIMP
      0.67954      0.73364

Single-equation diagnostics using reduced-form residuals:
DLEXP       : Portmanteau: degrees of freedom correction >= n^2*lag
DLEXP       : AR 1-5 test:      F(5,49)   =  0.15042 [0.9790]
DLEXP       : ARCH 1-4 test:    F(4,63)   =   2.3994 [0.0593]
DLEXP       : Normality test:   Chi^2(2)  =   16.780 [0.0002]**
DLEXP       : Hetero test:      F(32,38)  =   1.5921 [0.0848]
DLEXP       : Hetero-X test: not enough observations
DLIMP       : Portmanteau: degrees of freedom correction >= n^2*lag
DLIMP       : AR 1-5 test:      F(5,49)   =  0.19197 [0.9642]
DLIMP       : ARCH 1-4 test:    F(4,63)   =   2.4807 [0.0527]
DLIMP       : Normality test:   Chi^2(2)  =   9.2471 [0.0098]**
DLIMP       : Hetero test:      F(32,38)  =   1.4810 [0.1227]
DLIMP       : Hetero-X test: not enough observations

Portmanteau: degrees of freedom correction >= n^2*lag
Vector AR 1-5 test:      F(20,86)  =  0.37518 [0.9923]
Vector Normality test:   Chi^2(4)  =   14.091 [0.0070]**
Vector Hetero test:      F(96,108) =  0.88229 [0.7340]
Hetero-X test: not enough observations
Vector RESET23 test:     F(8,98)   =   4.5879 [0.0001]**
```

8 lags involve the use of many parameters, so it could be not easy to improve our model. Starting from the single equation for DLEXP, we can see that only 1st and 4th lags are significant, while in the DLIMP equation there is no significant lag at all. The **F-test on regressors show that only the 1st,3rd and 4th lags for DLEXP are fundamental** in the model. However, R^2 **has increased, while log-likelihood has decreased**. The **correlation of residuals did not change**, while the **correlation between actual and fitted has improved quite a lot**.
Looking at the tests, we can see **<u>improvement in the single equations, where the only problem left is the non-normality of residuals</u>**. **For the joint approach, there is non-normality and the linear form is not accurate**. If we look at the graphical representation:

We can see a nice improvement in fit, however, the big outlier from 2009 is not yet taken into account in the best way.

Let's try to make a model considering only the 1st lag for DLEXP and the 1st and 5th lags for DLIMP. These correspond to the lags used (and significant) in the best models for the respective single equations:

```
SYS(61) Estimating the system by OLS
        The estimation sample is: 2001(3) - 2019(4)

URF equation for: DLEXP
                  Coefficient  Std.Error  t-value  t-prob
DLEXP_1              0.523608     0.2108     2.48  0.0154
DLIMP_1            -0.0426909     0.1820   -0.235  0.8153
DLIMP_5            -0.0853151    0.08748   -0.975  0.3328
Constant      U    0.00414814   0.002965     1.40  0.1663

sigma = 0.0237857   RSS = 0.039603194

URF equation for: DLIMP
                  Coefficient  Std.Error  t-value  t-prob
DLEXP_1              0.629633     0.2270     2.77  0.0071
DLIMP_1           -0.00946693     0.1961  -0.0483  0.9616
DLIMP_5             -0.223735    0.09423    -2.37  0.0203
Constant      U    0.00328301   0.003194     1.03  0.3076

sigma = 0.0256216   RSS = 0.04595273832

log-likelihood      385.229796  -T/2log|Omega|      595.232699
|Omega|         1.03120231e-07  log|Y'Y/T|         -15.5851104
R^2(LR)               0.394838  R^2(LM)               0.204607
no. of observations         74  no. of parameters            8
```

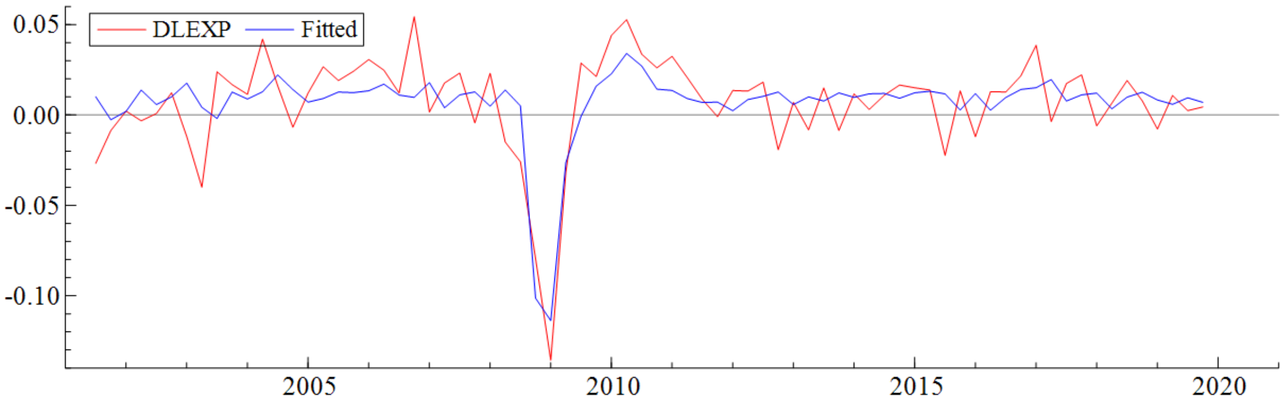
```
F-test on regressors except unrestricted: F(6,138) = 6.56597 [0.0000] **
F-tests on retained regressors, F(2,69) =
     DLEXP_1       3.84235 [0.026]*      DLIMP_1     0.0611977 [0.941]
     DLIMP_5       4.35562 [0.017]*     Constant U    0.992859 [0.376]

correlation of URF residuals (standard deviations on diagonal)
              DLEXP        DLIMP
DLEXP      0.023786      0.83049
DLIMP       0.83049     0.025622
correlation between actual and fitted
        DLEXP        DLIMP
      0.50374      0.60470

Single-equation diagnostics using reduced-form residuals:
DLEXP       : AR 1-5 test:      F(5,65)   =  0.64243 [0.6681]
DLEXP       : ARCH 1-4 test:    F(4,66)   =   2.7535 [0.0351]*
DLEXP       : Normality test:   Chi^2(2)  =   18.300 [0.0001]**
DLEXP       : Hetero test:      F(6,67)   =   3.4892 [0.0046]**
DLEXP       : Hetero-X test:    F(9,64)   =   2.7588 [0.0086]**
DLIMP       : AR 1-5 test:      F(5,65)   =  0.59365 [0.7048]
DLIMP       : ARCH 1-4 test:    F(4,66)   =   1.9504 [0.1124]
DLIMP       : Normality test:   Chi^2(2)  =   7.9032 [0.0192]*
DLIMP       : Hetero test:      F(6,67)   =   2.2012 [0.0535]
DLIMP       : Hetero-X test:    F(9,64)   =   1.6866 [0.1106]

Vector AR 1-5 test:      F(20,118) =   1.1312 [0.3281]
Vector Normality test:   Chi^2(4)  =   13.919 [0.0076]**
Vector Hetero test:      F(18,184) =   1.4485 [0.1137]
Vector Hetero-X test:    F(27,181) =   1.2048 [0.2348]
Vector RESET23 test:     F(8,130)  =   2.3386 [0.0222]*
```

We can see that only the 1st lag of DLEXP is significant in both equations, while the 5th lag for DLIMP is significant only in DLIMP's equation. R^2 and log-likelihood are worse now. We can see that are quite a few issues in the diagnostics, especially for DLEXP, so **this is not a good model**, simply. However, **<u>what will happen if in this same model we include the dummy variable for 2008(4)-2009(1)</u>** which has helped us so much while modeling the simple equations? Let's see:

```
SYS(62) Estimating the system by OLS
        The estimation sample is: 2001(3) - 2019(4)

URF equation for: DLEXP
                  Coefficient  Std.Error  t-value  t-prob
DLEXP_1              0.185188     0.1652     1.12  0.2662
DLIMP_1             0.0622028     0.1378    0.451  0.6531
DLIMP_5            -0.0922162    0.06589    -1.40  0.1661
dummy1+2            -0.102635    0.01391    -7.38  0.0000
Constant      U    0.00870774   0.002317     3.76  0.0004

sigma = 0.0179119   RSS = 0.02213774292

URF equation for: DLIMP
                  Coefficient  Std.Error  t-value  t-prob
DLEXP_1              0.314302     0.1948     1.61  0.1113
DLIMP_1             0.0882705     0.1625    0.543  0.5888
DLIMP_5             -0.230165    0.07770    -2.96  0.0042
dummy1+2           -0.0956325    0.01641    -5.83  0.0000
Constant      U    0.00753153   0.002733     2.76  0.0075

sigma = 0.0211239   RSS = 0.0307891448

log-likelihood     406.862227  -T/2log|Omega|      616.86513
|Omega|        5.74684044e-08  log|Y'Y/T|        -15.5851104
R^2(LR)              0.662746  R^2(LM)              0.372743
no. of observations        74  no. of parameters          10
```

```
F-test on regressors except unrestricted: F(8,136) = 12.2732 [0.0000] **
F-tests on retained regressors, F(2,68) =
     DLEXP_1       1.28631 [0.283]       DLIMP_1      0.148341 [0.862]
     DLIMP_5       4.96264 [0.010]**    dummy1+2       27.0090 [0.000]**
    Constant U     6.95911 [0.002]**

correlation of URF residuals (standard deviations on diagonal)
             DLEXP        DLIMP
DLEXP      0.017912      0.73369
DLIMP       0.73369     0.021124
correlation between actual and fitted
        DLEXP        DLIMP
      0.76345      0.75828

Single-equation diagnostics using reduced-form residuals:
DLEXP       : AR 1-5 test:      F(5,64)   =   1.8267 [0.1202]
DLEXP       : ARCH 1-4 test:    F(4,66)   =  0.32678 [0.8590]
DLEXP       : Normality test:   Chi^2(2)  =   1.7751 [0.4117]
DLEXP       : Hetero test:      F(7,66)   =  0.81917 [0.5748]
DLEXP       : Hetero-X test:    F(10,63)  =  0.55670 [0.8425]
DLIMP       : AR 1-5 test:      F(5,64)   =   1.2723 [0.2868]
DLIMP       : ARCH 1-4 test:    F(4,66)   =   1.3898 [0.2471]
DLIMP       : Normality test:   Chi^2(2)  =  0.73629 [0.6920]
DLIMP       : Hetero test:      F(7,66)   =  0.23649 [0.9747]
DLIMP       : Hetero-X test:    F(10,63)  =  0.38497 [0.9487]

Vector AR 1-5 test:      F(20,116) =   1.5775 [0.0699]
Vector Normality test:   Chi^2(4)  =   1.9182 [0.7508]
Vector Hetero test:      F(21,184) =  0.66913 [0.8596]
Vector Hetero-X test:    F(30,179) =  0.58876 [0.9563]
Vector RESET23 test:     F(8,128)  =   1.4554 [0.1800]
```

We have a **visible improvement** here. **Not all the parameters are significant**, however, R^2 **<u>is much higher, like log-likelihood</u>**. The c**orrelation of residuals has decreased a little**, while the **correlation between actual and fitted has increased**. Also, now the **<u>diagnostics' output is fine on all the fields</u>**. Here is the graphical representation for this model:



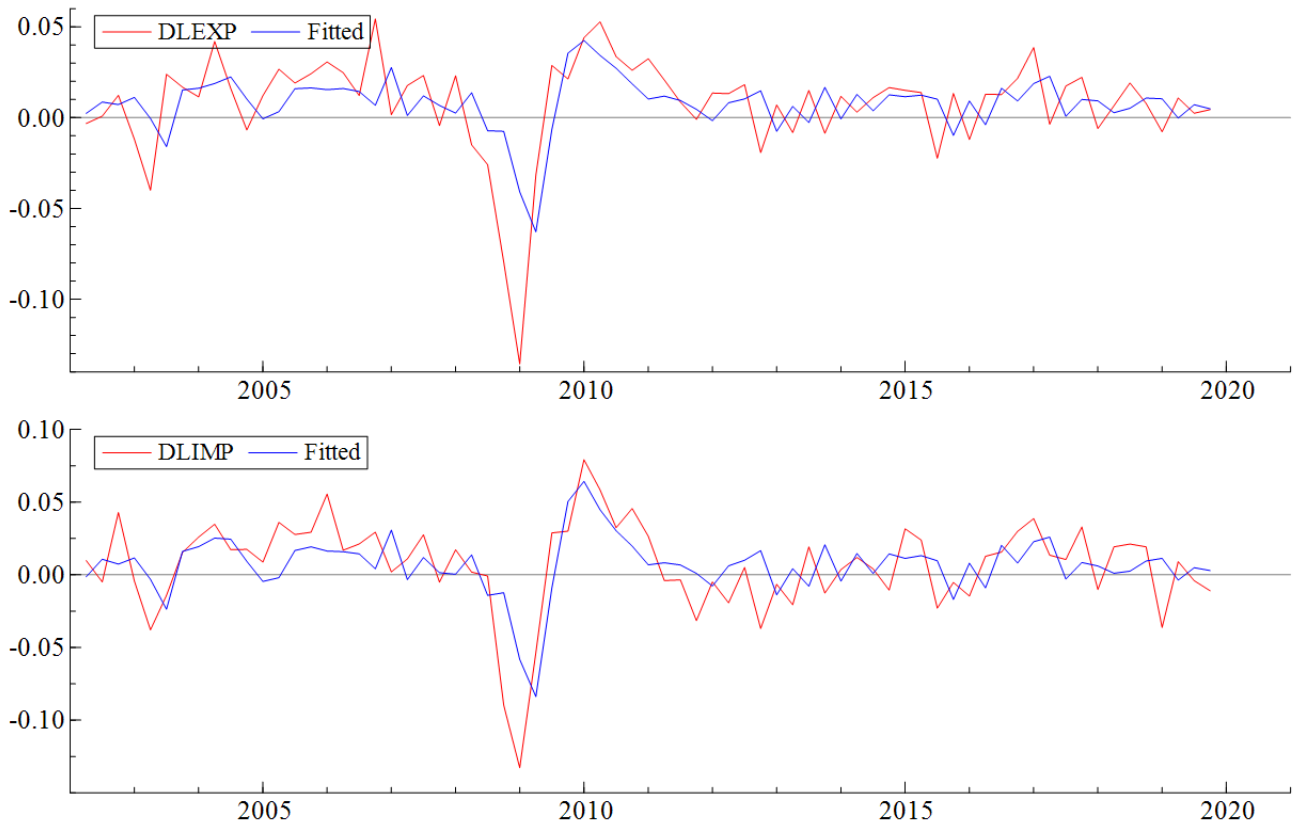
There has been an **improvement in fit**, for sure.

Now, we can try to use the Automatic model selection with 8 lags:

```
SYS(29) Estimating the system by OLS
        The estimation sample is: 2002(2) - 2019(4)

URF equation for: DLEXP
                  Coefficient  Std.Error  t-value  t-prob
DLEXP_1              0.522850     0.1025     5.10  0.0000
DLEXP_4             -0.193423     0.1012    -1.91  0.0602
Constant      U    0.00510731   0.002937     1.74  0.0866

sigma = 0.0231856   RSS = 0.03655494094

URF equation for: DLIMP
                  Coefficient  Std.Error  t-value  t-prob
DLEXP_1              0.684214     0.1091     6.27  0.0000
DLEXP_4             -0.337958     0.1078    -3.14  0.0025
Constant      U    0.00394250   0.003127     1.26  0.2117

sigma = 0.0246853   RSS = 0.04143663924

log-likelihood      372.292402  -T/2log|Omega|      573.781674
|Omega|         9.56218921e-08  log|Y'Y/T|         -15.6291531
R^2(LR)               0.413575  R^2(LM)               0.210031
no. of observations         71  no. of parameters            6

F-test on regressors except unrestricted: F(4,134) = 10.246 [0.0000] **
F-tests on retained regressors, F(2,67) =
     DLEXP_1       19.3738 [0.000]**     DLEXP_4       5.55703 [0.006]**
    Constant U     1.53682 [0.223]

correlation of URF residuals (standard deviations on diagonal)
              DLEXP        DLIMP
DLEXP      0.023186      0.82569
```

```
DLIMP        0.82569      0.024685
correlation between actual and fitted
        DLEXP        DLIMP
      0.54036      0.63422

Single-equation diagnostics using reduced-form residuals:
DLEXP       : AR 1-5 test:      F(5,63)    =  0.72148 [0.6098]
DLEXP       : ARCH 1-4 test:    F(4,63)    =   4.5614 [0.0027]**
DLEXP       : Normality test:   Chi^2(2)   =   16.671 [0.0002]**
DLEXP       : Hetero test:      F(4,66)    =   5.2645 [0.0010]**
DLEXP       : Hetero-X test:    F(5,65)    =   8.5666 [0.0000]**
DLIMP       : AR 1-5 test:      F(5,63)    =  0.36462 [0.8709]
DLIMP       : ARCH 1-4 test:    F(4,63)    =   2.0390 [0.0996]
DLIMP       : Normality test:   Chi^2(2)   =   12.923 [0.0016]**
DLIMP       : Hetero test:      F(4,66)    =   2.7598 [0.0348]*
DLIMP       : Hetero-X test:    F(5,65)    =   2.9526 [0.0183]*

Vector AR 1-5 test:       F(20,114) =   1.0003 [0.4676]
Vector Normality test:    Chi^2(4)  =   15.993 [0.0030]**
Vector Hetero test:       F(12,169) =   1.9722 [0.0295]*
Vector Hetero-X test:     F(15,174) =   3.2358 [0.0001]**
Vector RESET23 test:      F(8,126)  =   2.3810 [0.0201]*
```

We can see that the **Automatic model selection decided to leave only the 1st and 4th lag for DLEXP in both single equations**. However, we can see that the 4th lag is not significant in the single equation for DLEXP. According to the F-test, both lags are necessary. Unfortunately, **this model is definitely worse, as we can see that R^2 has decreased as well as log-likelihood and correlation between actual and fitted. The diagnostics show too many issues for this model**. We can see how the fit has worsened by looking at the graphical representation of the model too:



We can try to reproduce the model just created, adding the outlier and break detection:

```
SYS(31) Estimating the system by OLS
        The estimation sample is: 2001(2) - 2019(4)

URF equation for: DLEXP
                       Coefficient  Std.Error  t-value  t-prob
DLEXP_1                   0.284547    0.08074     3.52  0.0007
DLEXP_4                  -0.191231    0.07333    -2.61  0.0111
I:2009(1)+I:2008(4)      -0.100109    0.01330    -7.53  0.0000
Constant           U    0.00934006   0.002196     4.25  0.0001

sigma = 0.0172196   RSS = 0.02105252775

URF equation for: DLIMP
                       Coefficient  Std.Error  t-value  t-prob
DLEXP_1                   0.476589    0.09602     4.96  0.0000
DLEXP_4                  -0.334051    0.08721    -3.83  0.0003
I:2009(1)+I:2008(4)     -0.0911432    0.01582    -5.76  0.0000
Constant           U    0.00810837   0.002611     3.11  0.0027

sigma = 0.0204778   RSS = 0.02977307477

log-likelihood     413.960037  -T/2log|Omega|     626.800817
|Omega|        5.50684729e-08  log|Y'Y/T|        -15.5993134
R^2(LR)              0.672208  R^2(LM)              0.369866
no. of observations        75  no. of parameters           8

F-test on regressors except unrestricted: F(6,140) = 17.4213 [0.0000] **
F-tests on retained regressors, F(2,70) =
     DLEXP_1       12.1443 [0.000]**     DLEXP_4       7.24685 [0.001]**
I:2009(1)+I:2008(4)       28.0948 [0.000]**    Constant U     8.92551 [0.000]**

correlation of URF residuals (standard deviations on diagonal)
              DLEXP        DLIMP
DLEXP      0.017220      0.71120
DLIMP       0.71120     0.020478
correlation between actual and fitted
        DLEXP        DLIMP
      0.77751      0.76995

Single-equation diagnostics using reduced-form residuals:
DLEXP       : AR 1-5 test:      F(5,66)    =    2.1445 [0.0709]
DLEXP       : ARCH 1-4 test:    F(4,67)    =   0.52199 [0.7199]
DLEXP       : Normality test:   Chi^2(2)   =    1.5321 [0.4648]
DLEXP       : Hetero test:      F(5,69)    =  0.097708 [0.9922]
DLEXP       : Hetero-X test:    F(6,68)    =  0.096563 [0.9965]
DLIMP       : AR 1-5 test:      F(5,66)    =    1.8762 [0.1104]
DLIMP       : ARCH 1-4 test:    F(4,67)    =    1.4912 [0.2147]
DLIMP       : Normality test:   Chi^2(2)   =    4.3514 [0.1135]
DLIMP       : Hetero test:      F(5,69)    =   0.66082 [0.6543]
DLIMP       : Hetero-X test:    F(6,68)    =   0.55023 [0.7681]

Vector AR 1-5 test:      F(20,120) =   1.2522 [0.2253]
Vector Normality test:   Chi^2(4)  =   4.0070 [0.4051]
Vector Hetero test:      F(15,185) =  0.55209 [0.9075]
Vector Hetero-X test:    F(18,187) =  0.47402 [0.9664]
Vector RESET23 test:     F(8,132)  =  0.86163 [0.5507]
```

The tool has **created 2 dummy variables for 2008(4) and 2009(1)**. According to the F-test on regressors, the 1st and 4th lags for DLEXP are important, together with the dummy and the Constant.

We can see that **<u>this has improved R^2 and log-likelihood to its highest, the correlation of residuals (it is lower now) and the correlation between actual and fitted (it is greater)</u>**. Also, now all the tests present no anomaly. We can define this as the **<u>best multiple-equation model, in terms of parameters (all significant) and diagnostics</u>**.

If we look at the graphical representation:

We can see that the fit has improved, especially thanks to the dummy variables.

Before checking the effectiveness of forecasting, it would be proper to make a chronological summary of the multiple-equation models that were created so far:

- SYS(19), p.23;
- SYS(20), p.25;
- SYS(61), p.27;
- SYS(62), p.28;
- SYS(29), p.30;
- SYS(31), p.31.

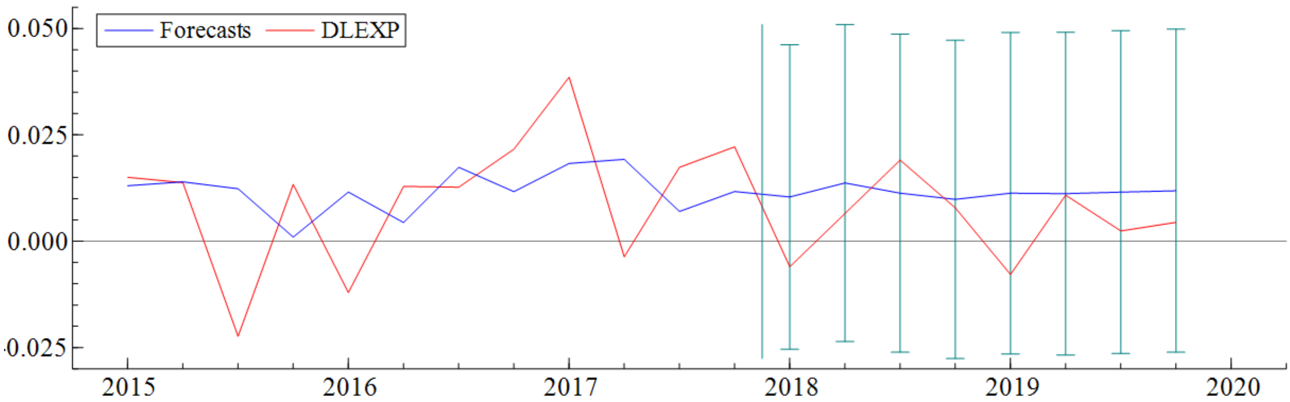
Out of these models, we can filter for those that were better in terms of significance of parameters or diagnostics. **SYS(19)** was a bad model as almost no lag was significant and the diagnostics showed many issues. R^2 and log-likelihood were very low and correlations were not good. **SYS(20)**, the manual model with 8 lags, had issues of parameters' significance, but otherwise was not a bad model, as the diagnostics didn't show many issues apart from non-normality of residuals; the fit was good, and the log-likelihood was high, the correlations had improved. **SYS(61)** had issues both in diagnostics and in parameters' significance. **SYS(62)** had some problems with parameters' significance, but diagnostics were very good, as well as correlations and log-likelihood and R^2. **SYS(29)** was not a good model in terms of diagnostics, while **SYS(31)** was just our best model.
This said, **we will create forecasts for SYS(20), SYS(62) and SYS(31)**.

We start with our last model, SYS(31), and we remove 8 forecasts from this model:

```
SYS(46) Estimating the system by OLS
```

```
        The estimation sample is: 2002(2) - 2017(4)

URF equation for: DLEXP
                       Coefficient  Std.Error  t-value  t-prob
DLEXP_1                   0.290426    0.08640     3.36  0.0014
DLEXP_4                  -0.158695    0.07948    -2.00  0.0505
I:2009(1)+I:2008(4)      -0.100842    0.01395    -7.23  0.0000
Constant           U     0.0100791   0.002479     4.07  0.0001

sigma = 0.0178948   RSS = 0.0188933048

URF equation for: DLIMP
                       Coefficient  Std.Error  t-value  t-prob
DLEXP_1                   0.474163    0.09681     4.90  0.0000
DLEXP_4                  -0.313270    0.08906    -3.52  0.0008
I:2009(1)+I:2008(4)     -0.0921208    0.01563    -5.89  0.0000
Constant           U    0.00876467   0.002778     3.16  0.0025

sigma = 0.0200522   RSS = 0.0237234238

log-likelihood     348.117377  -T/2log|Omega|     526.903632
|Omega|        5.43892442e-08  log|Y'Y/T|        -15.4905504
R^2(LR)              0.709615  R^2(LM)              0.397061
no. of observations        63  no. of parameters           8

F-test on regressors except unrestricted: F(6,116) = 16.544 [0.0000] **
F-tests on retained regressors, F(2,58) =
     DLEXP_1       11.8177 [0.000]**     DLEXP_4       6.37499 [0.003]**
I:2009(1)+I:2008(4)       26.1596 [0.000]**    Constant U     8.17953 [0.001]**

correlation of URF residuals (standard deviations on diagonal)
              DLEXP        DLIMP
DLEXP      0.017895      0.71998
DLIMP       0.71998     0.020052
correlation between actual and fitted
        DLEXP        DLIMP
      0.79350      0.80103

Single-equation diagnostics using reduced-form residuals:
DLEXP       : AR 1-4 test:      F(4,55)   =   2.0296 [0.1029]
DLEXP       : ARCH 1-4 test:    F(4,55)   =  0.61620 [0.6528]
DLEXP       : Normality test:   Chi^2(2)  =   1.8511 [0.3963]
DLEXP       : Hetero test:      F(5,57)   =  0.29904 [0.9114]
DLEXP       : Hetero-X test:    F(6,56)   =  0.24755 [0.9583]
DLIMP       : AR 1-4 test:      F(4,55)   =   2.1037 [0.0927]
DLIMP       : ARCH 1-4 test:    F(4,55)   =   1.8455 [0.1333]
DLIMP       : Normality test:   Chi^2(2)  =   3.1502 [0.2070]
DLIMP       : Hetero test:      F(5,57)   =  0.48764 [0.7841]
DLIMP       : Hetero-X test:    F(6,56)   =  0.43713 [0.8509]

Vector AR 1-4 test:      F(16,100) =   1.3157 [0.2027]
Vector Normality test:   Chi^2(4)  =   2.1499 [0.7082]
Vector Hetero test:      F(15,152) =  0.46538 [0.9544]
Vector Hetero-X test:    F(18,153) =  0.40938 [0.9844]
Vector RESET23 test:     F(8,108)  =  0.73181 [0.6632]

1-step (ex post) forecast analysis 2018(1) - 2019(4)
Parameter constancy forecast tests:
using Omega  Chi^2(16) =   12.099 [0.7372]   F(16,59)  =  0.75616 [0.7258]
using  V[e]  Chi^2(16) =   11.846 [0.7545]   F(16,59)  =  0.74037 [0.7421]
using  V[E]  Chi^2(16) =   11.958 [0.7469]   F(16,59)  =  0.74735 [0.7349]
```

As we can see, the **model is quite similar**, however log-likelihood has reduced and now there are 8 forecasts less. We can check the forecasting ability of the model:



And if we look at the written results:

Dynamic (ex ante) forecasts for DLEXP (SE based on error variance only)

Horizon	Forecast	SE	Actual	Error	t-value	-2SE	+2SE
2018(1)	0.0104021	0.01789	-0.00600460	-0.016407	-0.917	-0.025388	0.046192
2018(2)	0.0136836	0.01863	0.00651526	-0.0071684	-0.385	-0.023585	0.050952
2018(3)	0.0112951	0.01870	0.0190763	0.0077812	0.416	-0.026095	0.048686
2018(4)	0.00983867	0.01870	0.00783537	-0.0020033	-0.107	-0.027562	0.047240
2019(1)	0.0112858	0.01890	-0.00781965	-0.019105	-1.011	-0.026506	0.049078
2019(2)	0.0111853	0.01896	0.0108366	-0.00034867	-0.018	-0.026744	0.049115
2019(3)	0.0115351	0.01898	0.00240731	-0.0091278	-0.481	-0.026421	0.049491
2019(4)	0.0118679	0.01898	0.00443094	-0.0074369	-0.392	-0.026092	0.049828

mean(Error) = -0.0067270 RMSE = 0.010541
SD(Error) = 0.0081153 MAPE = 155.52

Dynamic (ex ante) forecasts for DLIMP (SE based on error variance only)

Horizon	Forecast	SE	Actual	Error	t-value	-2SE	+2SE
2018(1)	0.00720246	0.02005	-0.0101321	-0.017335	-0.864	-0.032902	0.047307
2018(2)	0.0148487	0.02177	0.0192653	0.0044166	0.203	-0.028698	0.058396
2018(3)	0.00980838	0.02191	0.0211795	0.011371	0.519	-0.034017	0.053634
2018(4)	0.00717012	0.02192	0.0192809	0.012111	0.552	-0.036678	0.051019
2019(1)	0.0101711	0.02258	-0.0362424	-0.046414	-2.056	-0.034987	0.055329
2019(2)	0.00982930	0.02277	0.00906172	-0.00076757	-0.034	-0.035703	0.055362
2019(3)	0.0105299	0.02280	-0.00404534	-0.014575	-0.639	-0.035070	0.056130
2019(4)	0.0111520	0.02280	-0.0109718	-0.022124	-0.970	-0.034458	0.056762

mean(Error) = -0.0091645 RMSE = 0.020775
SD(Error) = 0.018644 MAPE = 126.12

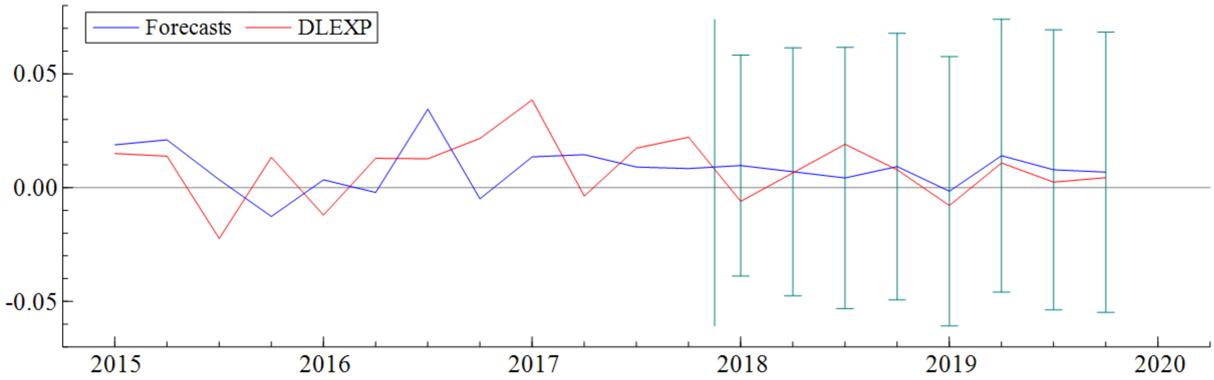
We can see that the **values of RMSE and MAPE are quite low for these forecasts**, which is good (we would like these values to be as low as possible).

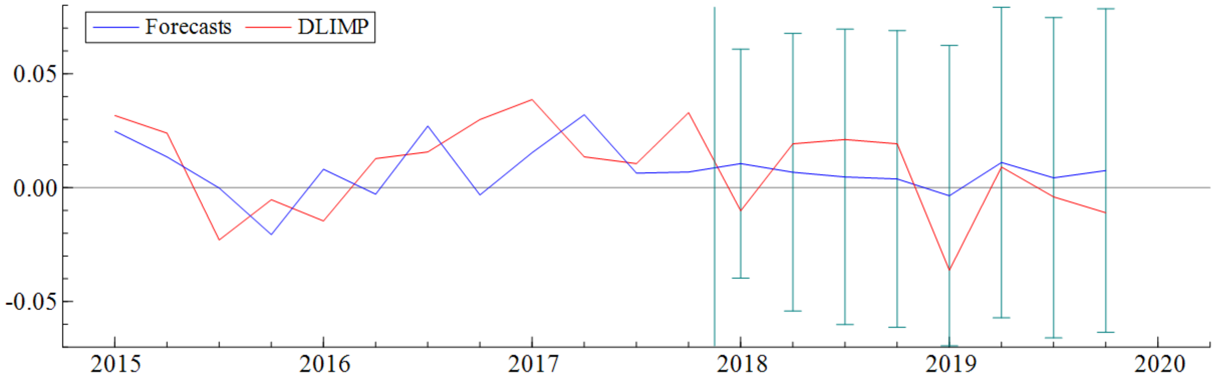
Now, we will try to see if the forecasts made on the base of model SYS(20) that was built before (8 lags with no Automatic model selection) will be better than these. Here is the model less 8 forecasts:

```
SYS(47) Estimating the system by OLS
        The estimation sample is: 2002(2) - 2017(4)

URF equation for: DLEXP
                  Coefficient  Std.Error  t-value  t-prob
DLEXP_1              0.617215     0.2697     2.29  0.0267
DLEXP_2              0.405951     0.2890     1.40  0.1669
DLEXP_3              0.252259     0.2696    0.936  0.3543
DLEXP_4             -0.365746     0.2935    -1.25  0.2190
DLEXP_5             -0.309202     0.2944    -1.05  0.2991
DLEXP_6             -0.485045     0.2685    -1.81  0.0774
DLEXP_7              0.258414     0.2816    0.918  0.3636
DLEXP_8             -0.300179     0.2689    -1.12  0.2701
DLIMP_1             -0.125537     0.2563   -0.490  0.6266
DLIMP_2             -0.484340     0.2561    -1.89  0.0649
DLIMP_3            -0.0523275     0.2575   -0.203  0.8398
DLIMP_4              0.173570     0.2596    0.669  0.5071
DLIMP_5              0.224505     0.2261    0.993  0.3259
DLIMP_6              0.374074     0.2215     1.69  0.0981
DLIMP_7             -0.318142     0.2297    -1.38  0.1728
DLIMP_8              0.191631     0.2013    0.952  0.3462
Constant      U    0.00742783   0.003693     2.01  0.0502

sigma = 0.024254   RSS = 0.02705988296

URF equation for: DLIMP
                  Coefficient  Std.Error  t-value  t-prob
DLEXP_1              0.782471     0.2795     2.80  0.0075
DLEXP_2              0.313587     0.2996     1.05  0.3007
DLEXP_3             -0.222478     0.2795   -0.796  0.4301
DLEXP_4             -0.644475     0.3042    -2.12  0.0396
DLEXP_5             -0.283070     0.3052   -0.928  0.3584
DLEXP_6             -0.186136     0.2783   -0.669  0.5070
DLEXP_7              0.348573     0.2919     1.19  0.2386
DLEXP_8             -0.237068     0.2788   -0.850  0.3995
DLIMP_1            -0.0854146     0.2656   -0.322  0.7493
DLIMP_2             -0.275156     0.2654    -1.04  0.3053
DLIMP_3              0.256657     0.2669    0.962  0.3412
DLIMP_4              0.351113     0.2691     1.30  0.1984
DLIMP_5             0.0359529     0.2343    0.153  0.8787
DLIMP_6              0.227502     0.2296    0.991  0.3270
DLIMP_7             -0.441454     0.2381    -1.85  0.0702
DLIMP_8              0.217498     0.2087     1.04  0.3028
Constant      U    0.00577256   0.003828     1.51  0.1384

sigma = 0.0251408   RSS = 0.02907465183

log-likelihood     346.556423  -T/2log|Omega|     525.342678
|Omega|        5.71523493e-08  log|Y'Y/T|        -15.4905504
R^2(LR)              0.694863  R^2(LM)              0.431087
no. of observations        63  no. of parameters          34

F-test on regressors except unrestricted: F(32,90) = 2.27899 [0.0013] **
F-tests on retained regressors, F(2,45) =
     DLEXP_1       3.84140 [0.029]*     DLEXP_2      0.997221 [0.377]
     DLEXP_3       4.69258 [0.014]*     DLEXP_4       2.69131 [0.079]
     DLEXP_5      0.542525 [0.585]      DLEXP_6       2.83702 [0.069]
     DLEXP_7      0.711109 [0.497]      DLEXP_8      0.623561 [0.541]
     DLIMP_1      0.131636 [0.877]      DLIMP_2       2.28002 [0.114]
     DLIMP_3       2.19866 [0.123]      DLIMP_4       1.14968 [0.326]
     DLIMP_5       1.27696 [0.289]      DLIMP_6       1.71400 [0.192]
     DLIMP_7       1.73528 [0.188]      DLIMP_8      0.540247 [0.586]
```

```
    Constant U     2.03949 [0.142]

correlation of URF residuals (standard deviations on diagonal)
              DLEXP        DLIMP
DLEXP      0.024254      0.84361
DLIMP       0.84361     0.025141
correlation between actual and fitted
        DLEXP        DLIMP
      0.68524      0.74887

Single-equation diagnostics using reduced-form residuals:
DLEXP       : Portmanteau: degrees of freedom correction >= n^2*lag
DLEXP       : AR 1-4 test:      F(4,42)   =  0.16880 [0.9531]
DLEXP       : ARCH 1-4 test:    F(4,55)   =   2.0110 [0.1056]
DLEXP       : Normality test:   Chi^2(2)  =   13.956 [0.0009]**
DLEXP       : Hetero test:      F(32,30)  =   2.0535 [0.0253]*
DLEXP       : Hetero-X test: not enough observations
DLIMP       : Portmanteau: degrees of freedom correction >= n^2*lag
DLIMP       : AR 1-4 test:      F(4,42)   =  0.16967 [0.9527]
DLIMP       : ARCH 1-4 test:    F(4,55)   =   2.6523 [0.0426]*
DLIMP       : Normality test:   Chi^2(2)  =   9.4493 [0.0089]**
DLIMP       : Hetero test:      F(32,30)  =   1.3806 [0.1887]
DLIMP       : Hetero-X test: not enough observations

Portmanteau: degrees of freedom correction >= n^2*lag
Vector AR 1-4 test:      F(16,74)  =  0.40251 [0.9779]
Vector Normality test:   Chi^2(4)  =   10.220 [0.0369]*
Vector Hetero test:      F(96,84)  =   1.1410 [0.2687]
Hetero-X test: not enough observations
Vector RESET23 test:     F(8,82)   =   4.7459 [0.0001]**

1-step (ex post) forecast analysis 2018(1) - 2019(4)
Parameter constancy forecast tests:
using Omega  Chi^2(16) =   10.873 [0.8173]   F(16,46)  =  0.67956 [0.7984]
using  V[e]  Chi^2(16) =   9.4370 [0.8943]   F(16,46)  =  0.58981 [0.8752]
using  V[E]  Chi^2(16) =   10.040 [0.8645]   F(16,46)  =  0.62749 [0.8448]
```

As we can see, **there are some issues with diagnostics now** (as there were in this same model when built without the exclusion of the last 8 forecasts at p. 25) and the correlation of residuals has become quite high. But if we look at the forecasts for the last 8 periods:





<u>**We can see that the situation has surprisingly improved**</u>! This comes along with the fact <u>**that a good specification in terms of parameters doesn't have to be as good in terms of forecasting, and vice versa**</u>. And if we look at the written results:

```
Dynamic (ex ante) forecasts for DLEXP (SE based on error variance only)
   Horizon       Forecast         SE        Actual        Error   t-value        -2SE        +2SE
   2018(1)     0.00972599    0.02425   -0.00600460    -0.015731    -0.649   -0.038782    0.058234
   2018(2)     0.00699643    0.02725    0.00651526  -0.00048117    -0.018   -0.047505    0.061498
   2018(3)     0.00427044    0.02869     0.0190763     0.014806     0.516   -0.053109    0.061650
   2018(4)     0.00927177    0.02930    0.00783537   -0.0014364    -0.049   -0.049336    0.067880
   2019(1)    -0.00154729    0.02959   -0.00781965   -0.0062724    -0.212   -0.060723    0.057628
   2019(2)      0.0140471    0.02999     0.0108366   -0.0032105    -0.107   -0.045939    0.074033
   2019(3)     0.00784572    0.03077    0.00240731   -0.0054384    -0.177   -0.053701    0.069392
   2019(4)     0.00683768    0.03080    0.00443094   -0.0024067    -0.078   -0.054761    0.068437
   mean(Error) =    -0.0025213     RMSE =    0.0083215
   SD(Error)   =     0.0079303     MAPE =       94.422

Dynamic (ex ante) forecasts for DLIMP (SE based on error variance only)
   Horizon       Forecast         SE        Actual        Error   t-value        -2SE        +2SE
   2018(1)      0.0105830    0.02514    -0.0101321    -0.020715    -0.824   -0.039699    0.060864
   2018(2)     0.00681453    0.03046     0.0192653     0.012451     0.409   -0.054114    0.067743
   2018(3)     0.00472461    0.03242     0.0211795     0.016455     0.508   -0.060119    0.069568
   2018(4)     0.00383575    0.03257     0.0192809     0.015445     0.474   -0.061307    0.068979
   2019(1)    -0.00353272    0.03297    -0.0362424    -0.032710    -0.992   -0.069472    0.062407
   2019(2)      0.0110693    0.03409    0.00906172   -0.0020076    -0.059   -0.057117    0.079255
   2019(3)     0.00434946    0.03516   -0.00404534   -0.0083948    -0.239   -0.065969    0.074668
   2019(4)     0.00754973    0.03551    -0.0109718    -0.018522    -0.522   -0.063469    0.078568
   mean(Error) =    -0.0047497     RMSE =     0.017962
   SD(Error)   =      0.017322     MAPE =       114.45
```

We have a **great improvement**, especially in terms of MAPE, which is much lower in this model.

To sum up, <u>we have seen two best models for different reasons; namely, we had a **best model in terms of parameters and tests**, which was an initial 8-lag model created with Automatic model</u>

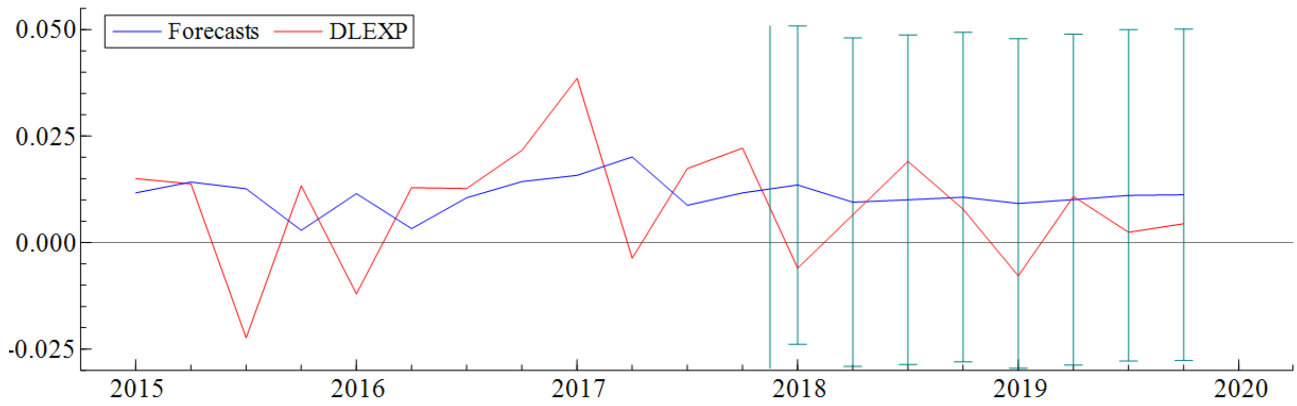
selection and outlier and break detection, which was reduced to only 1st and 4th lag of DLEXP, a constant and two dummy variables by the model selection (p. 31, SYS(31), less forecasts at p.33 SYS(46)). The other model, an initial 8-lag model with no Automatic model selection and no outlier or break detection (p. 25 SYS(20), less forecasts at p. 35 SYS(47)), didn't have particularly nice results from diagnostics, but it had **much better forecasts**.

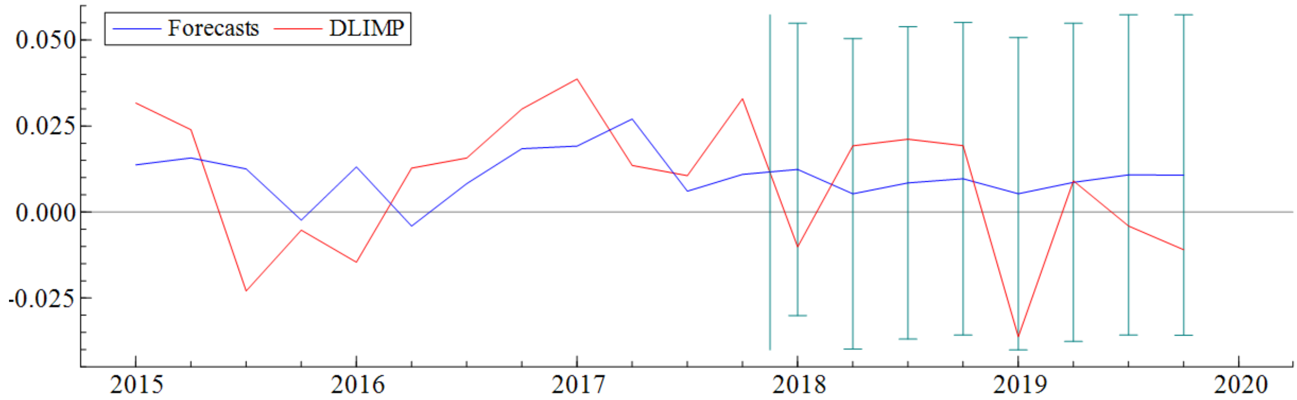
There is still room for SYS(62), the model which was created using only 1st lag for DLEXP and the 1st and 5th lags for DLIMP, with the addition of a dummy variable accounting for 2008(4)-2009(1). Let's remove the last 8 forecasts for this model:

```
SYS(63) Estimating the system by OLS
        The estimation sample is: 2001(3) - 2017(4)

URF equation for: DLEXP
                  Coefficient  Std.Error  t-value  t-prob
DLEXP_1              0.163570     0.1763    0.928  0.3573
DLIMP_1             0.0948689     0.1503    0.631  0.5303
DLIMP_5            -0.0756062    0.07063    -1.07  0.2886
dummy1+2            -0.102795    0.01455    -7.06  0.0000
Constant      U    0.00902063   0.002529     3.57  0.0007

sigma = 0.0186875   RSS = 0.02130252429

URF equation for: DLIMP
                  Coefficient  Std.Error  t-value  t-prob
DLEXP_1              0.279425     0.2005     1.39  0.1685
DLIMP_1              0.137564     0.1709    0.805  0.4240
DLIMP_5             -0.208951    0.08031    -2.60  0.0116
dummy1+2           -0.0958606    0.01655    -5.79  0.0000
Constant      U    0.00791464   0.002875     2.75  0.0078

sigma = 0.0212478   RSS = 0.02753961163

log-likelihood     360.236765  -T/2log|Omega|     547.536651
|Omega|        6.22554512e-08  log|Y'Y/T|        -15.4470381
R^2(LR)               0.68177  R^2(LM)               0.38547
no. of observations        66  no. of parameters          10

F-test on regressors except unrestricted: F(8,120) = 11.5902 [0.0000] **
F-tests on retained regressors, F(2,60) =
     DLEXP_1      0.964647 [0.387]       DLIMP_1      0.320366 [0.727]
     DLIMP_5       4.07595 [0.022]*     dummy1+2       24.9411 [0.000]**
    Constant U     6.27822 [0.003]**

correlation of URF residuals (standard deviations on diagonal)
               DLEXP        DLIMP
DLEXP      0.018687      0.73331
DLIMP       0.73331     0.021248
correlation between actual and fitted
        DLEXP        DLIMP
      0.77082      0.77664

Single-equation diagnostics using reduced-form residuals:
DLEXP       : AR 1-5 test:      F(5,56)   =   1.5369 [0.1932]
DLEXP       : ARCH 1-4 test:    F(4,58)   =  0.40500 [0.8043]
DLEXP       : Normality test:   Chi^2(2)  =   2.5729 [0.2763]
DLEXP       : Hetero test:      F(7,58)   =  0.74325 [0.6364]
DLEXP       : Hetero-X test:    F(10,55)  =  0.50159 [0.8816]
DLIMP       : AR 1-5 test:      F(5,56)   =   1.3660 [0.2510]
DLIMP       : ARCH 1-4 test:    F(4,58)   =   1.2488 [0.3006]
DLIMP       : Normality test:   Chi^2(2)  =  0.38454 [0.8251]
DLIMP       : Hetero test:      F(7,58)   =  0.34235 [0.9310]
DLIMP       : Hetero-X test:    F(10,55)  =  0.43300 [0.9240]
```

```
Vector AR 1-5 test:      F(20,100) =   1.5975 [0.0679]
Vector Normality test:   Chi^2(4)  =   1.2751 [0.8656]
Vector Hetero test:      F(21,161) =  0.66789 [0.8596]
Vector Hetero-X test:    F(30,156) =  0.56602 [0.9657]
Vector RESET23 test:     F(8,112)  =   1.3541 [0.2246]

1-step (ex post) forecast analysis 2018(1) - 2019(4)
Parameter constancy forecast tests:
using Omega  Chi^2(16) =   9.8467 [0.8745]   F(16,61)  =  0.61542 [0.8592]
using  V[e]  Chi^2(16) =   9.5135 [0.8908]   F(16,61)  =  0.59460 [0.8758]
using  V[E]  Chi^2(16) =   9.6136 [0.8860]   F(16,61)  =  0.60085 [0.8709]
```

The diagnostics are still fine here, but let's look at the forecasts for the last 8 periods:






```
Dynamic (ex ante) forecasts for DLEXP (SE based on error variance only)
   Horizon       Forecast        SE         Actual        Error    t-value        -2SE         +2SE
   2018(1)      0.0135143   0.01869   -0.00600460    -0.019519     -1.044   -0.023861     0.050889
   2018(2)     0.00948106   0.01928    0.00651526   -0.0029658     -0.154   -0.029076     0.048038
   2018(3)      0.0100508   0.01934     0.0190763    0.0090255      0.467   -0.028623     0.048724
   2018(4)      0.0106676   0.01934    0.00783537   -0.0028322     -0.146   -0.028017     0.049353
   2019(1)     0.00918981   0.01934   -0.00781965    -0.017009     -0.879   -0.029496     0.047876
   2019(2)      0.0100929   0.01941     0.0108366   0.00074370      0.038   -0.028720     0.048905
   2019(3)      0.0110885   0.01944    0.00240731   -0.0086812     -0.446   -0.027799     0.049976
   2019(4)      0.0112202   0.01945    0.00443094   -0.0067893     -0.349   -0.027687     0.050128
   mean(Error) =    -0.0060035    RMSE =      0.010551
   SD(Error)   =     0.0086766    MAPE =        149.03

Dynamic (ex ante) forecasts for DLIMP (SE based on error variance only)
   Horizon       Forecast        SE         Actual        Error    t-value        -2SE         +2SE
   2018(1)      0.0123932   0.02125    -0.0101321    -0.022525     -1.060   -0.030102     0.054889
   2018(2)     0.00530969   0.02258     0.0192653     0.013956      0.618   -0.039842     0.050461
   2018(3)     0.00846316   0.02270     0.0211795     0.012716      0.560   -0.036937     0.053863
   2018(4)     0.00967660   0.02271     0.0192809    0.0096043      0.423   -0.035748     0.055101
   2019(1)     0.00533474   0.02271    -0.0362424    -0.041577     -1.831   -0.040092     0.050762
   2019(2)     0.00862681   0.02313    0.00906172   0.00043491      0.019   -0.037635     0.054889
```

```
2019(3)     0.0108121   0.02327   -0.00404534   -0.014857    -0.638   -0.035731    0.057356
2019(4)     0.0107320   0.02330    -0.0109718   -0.021704    -0.931   -0.035871    0.057335
mean(Error) =   -0.0079941    RMSE =    0.020545
SD(Error)   =     0.018926    MAPE =      136.15
```

Both the graphs and the written results witness against the forecasts from this specification; they are quite similar to those from SYS(20), so **SYS(31) stays as the best model for forecasting** in this case.