THE ASSESSMENT OF PARAMETER UNCERTAINTY IN A VECTOR ERROR CORRECTION MODEL FOR ROMANIA

Author[1]:
Mihaela SIMIONESCU

***A**bstract*: *The assessment of uncertainty that characterizes the econometric model parameters is an important input for policymakers that have to establish more alternative policies to protect against persistent shocks of the economy. The objective of this useful research for policymakers is to evaluate the parameter uncertainty in the behavioural equations of a vector error correction model for Romania. A positive impact of the foreign direct investment and exports on GDP real rate was measured on the horizon Q1:2000-Q4:2012. A permanent shock was observed in parameters. The error correction vector explains quarterly around 10.6% of the desequilibrium. The necessary period for reducing the gap between the value of GDP in the last quarter of 2012 and that in the steady-state is 14 quarters, till the second quarter of 2016.*

Keywords: *parameters uncertainty, vector error correction model, behavioural equations, steady-state, GDP rate, foreign direct investments, exports*

JEL Classification: *C51, C59, E61*

1. Introduction

The evaluation of parameter uncertainty in econometric models presents a considerable interest for policymakers, especially for monetary policymakers. Few studies analysed this source of uncertainty in modelling. The obvious shocks that affect the economy enforce its effects on the parameter uncertainty, but also on the overall model uncertainty. Therefore, it is necessary for the

[1] PhD, Bucharest University of Economics, Faculty of Economic Cybernetics, Statistics and Informatics, e-mails: mihaela_mb1@yahoo.com , Mihaela.Simionescu@csie.ase.ro

policymakers to take into consideration more optional policies, their alternatives being in accordance with different degrees of uncertainty in the parameters and data. Economists tried to find proper ways for measuring the coefficient uncertainty, most of the research using stochastic simulations like Monte Carlo methods or bootstrapping procedures.

The objective of this research is to assess the parameter uncertainty for the behavioural equations in a vector-error-correction model (VECM) built for evaluating the effect of direct foreign investments and exports on Romanian GDP. The results revealed a permanent shock in the parameters. According to Mahika and Ditu-Furtuna (2012), the uncertainty increased very much in the actual economic crisis.

2. Literature

The parameters in the economic model revealed the interactions within that model. For example, the parameters show how sensitive export or investment is to a 1 percentage point change in the real GDP rate. Statistical methods are used to estimate these unknown parameters. The econometricians used only a limited quantity of data, a sample, to provide “approximations” to these parameters. These approximations are called “estimators”, being affected by errors or uncertainty, because the estimations are not the real values.

Brainard (1967) was the first one who showed how the parameter uncertainty affects the decisional process of the policymakers. The variable evolution should be motorized in order to make the proper policy’s adjustments. The real limit of intuitive finding of Brainard (1967) is that it did not support generalization. Söderström (2002) showed if the persistence of inflation is uncertain, the policymakers may respond aggressively to inflation augmentation in order to protect against persistent shocks.

Greenspan (2003) considered that central banks developed a “risk-management” approach to the policies by taking into account the probabilities for some possible events and the effects in each case.

Few recent studies have found that parameter uncertainty is not a major problem for the government. Rudebusch (2001) assessed the parameter uncertainty for a macroeconometric model built for USA. The author revealed a minor effect of the parameter uncertainty of his model. Abler, Rodriguez and Shortler (1999) assessed the uncertainty of parameters for a CGE model built to show the influence of sectoral and macroeconomic policies on environment in Costa Rica.

The model coefficients are assimilated to random variables and Monte Carlo experiments are considered. The authors obtained quite robust effects of the policy scenarios on the environmental variables.

Orphanides and Williams (2005) and Refet, Sack and Swanson (2005) explained the cause of choosing monetary policy with inflation target for some countries. They showed that better results for the policy can be obtained if the degree of uncertainty of firms and households regarding the future evolution on inflation is diminished.

Cicarelli şi Hubrich (2010) presented a detailed retrospective regarding the sources of uncertainty in forecasting. More classifications of the sources of uncertainty are presented, the most well described being related to informational uncertainty, the uncertainty determined by the use of a model (the model imprecision and its associated prediction, the selection of the best model, the forecast assessment) and measurement uncertainty.

In literature, there are 3 approaches based on models: mathematical, economical and systemic. The mathematical approach includes 6 sources of uncertainty. The parameter uncertainty is placed among the uncertainty generated by: omitted variables, exogenous variables, form of the variable, uncertainty related to the stability of the relationship between variables and structural uncertainty

Fair (1993) assessed the parameter uncertainty and the uncertainty generated by the errors in a model for USA, using a stochastic simulation. The model uncertainty was later evaluated by Fair (2003) using bootstrapping simulations.

The uncertainty analysis regarding the selection of the best model was rarely described in econometrics, in statistics being treated from the informational criterion viewpoint.

Lanser and Kranendonk (2008) identified 4 sources of uncertainty in forecasting. The uncertainty in the parameters of behavioural equations is presented besides data uncertainty, exogenous variables uncertainty and the imprecision in measuring the errors.

The parameter uncertainty could be fixed or estimated. In the estimation process, the approximated values of the parameters in the behavioural equations are determined. The estimated coefficients allow us to make a description of the past evolution of an economic phenomenon, the econometrical approach being combined with the economic one. For the fixed parameters, the results determined using the econometrical models are adapted to experts' opinions. The professionals' expectations make the uncertainty difficult to measure.

3. The uncertainty of parameters associated to behavioural equations

Engle and Granger (1987) showed that for behavioural equations, in most cases, the model is an error correction one in the short-run and long-run. The growth rate of the endogenous variable is computed using the short-run equation and the deviation of this variable compared to the equilibrium value is partially corrected. The long-run equations present the relationship between the exogenous variables and the long-run equilibrium. The parameter denoted by ”v” is used in the short-run equation, measuring the adjustment speed of the dependent variable compared to its equilibrium.

The form of the short-run equation (SR):

$$y(t) = x_{SR}^{T}(t) \cdot \beta_{SR} - v \cdot (\ln y(t) - \ln y^{*}(t)) \tag{1}$$

The form of the long-run equation (LR):

$$\ln y^{*}(t) = x_{LR}^{T}(t) \cdot \beta_{LR} + ct\, ,\; t = 1,...,T \tag{2}$$

Where:

$y^{*}(t)$ - the value of the endogenous variable on the long-run equilibrium

$x_{LR}^{T}(t)$ - the vector that includes exogenous variables

ct - the constant of long-run model.

It is assumed that the parameters of a behavioural equation are correlated, but the parameters from different equations are not correlated.

The following relationship is used to measure the parameter uncertainty:

$(\beta_{SR}, v, \beta_{LR}, ct) = (\hat{\beta}_{SR}, \hat{v}, \hat{\beta}_{LR}, \hat{ct})^{T} + u = \hat{\mu} + e, e \to N(0, \Sigma), where\ \Sigma -$ covariance matrix of the errors (3)

The covariance matrix of the errors shows the uncertainty of the estimated parameters and it does have a fixed form. Its elements depend on the estimation method of the parameters. The error variance for the estimated fixed parameters is based on experts’ appreciations.

The purpose was to model the impact of foreign direct investments and exports on GDP real rate for Romania in the period 2000-2012, using quarterly data. Firstly, a multiple linear regression model is built using the absolute values expressed in comparable prices, the reference being the year 2000. For a 5% level of significance, the model was validated. The coefficient of determination is almost 1, the parameters being significantly different from zero.

A model based on annual data is also constructed, but the rates of the variables are used. The data are based on the transformation of the original data sets provided by the National Institute of Statistics and the International Monetary Fund. In this model the impact of foreign direct investments and exports on GDP real rate is explained:

$$r\_GDP = -0.7153 + 0.189 \cdot r\_EXP + 0.273 \cdot r\_FDI$$

The elasticity of the foreign direct investments is 0.273 and it shows that the FDI will grow by 2.73 percentage points for each increase in the GDP rate by 1 percetange point, the influence of exports being insignificant.

Using the quarterly data provided by the International Monetary Fund in Q1:2000-Q4:2012 for the mentioned variables in comparable prices of 2000, the long-run relationship between GDP and causal variables is described. The variables are transformed by logarithm, followed by seasonal adjustment using the Tramo/Seats method in EViews.

If the data series are stationary, the causality is described using a VAR (vector auto-regressive) model. If the data sets are not stationary, having the same order, a co-integration relationship is determined and a vector error correction model (VECM) is estimated. The VECM combines a VAR with an error correction model (ECM).

The VAR model based on 3 variables is built as:

$$X_t = A_0 + A(\log)X_t + \varepsilon_t, \quad A(\log) - 3\times 3 \textit{ matrix of the polynom is}: a_{ij}(\log) = \sum a_{ij}^{\ 1} \log^1$$
$$A_0 = (a_{10}a_{20}a_{30}) - constants \quad (4)$$
$$\varepsilon_t - eroarea$$

For non-stationary series, if there is at least one cointegration vector, the VECM is:

$$\Delta X_t = A_0 + A(\log)\Delta X_{t-1} + \alpha EC_{t-1} + \mu_t \quad (5)$$

μ_t -errors vector of null mean

The term of errors correction is represented as:

$$EC_t = \ln PIB_t - \beta_1 \cdot \ln ISD_t - \beta_2 \cdot \ln EXP_t$$

The final form of the model is:

$$\Delta \log PIB_t = a_0 + \sum a_{1j} \Delta \log PIB_{t-j} + \sum a_{2j} \Delta \log ISD_{t-j} + \sum a_{3j} \Delta \log EXP_{t-j} + v \cdot EC_{t-1} + \varepsilon_t \quad (6)$$

The "v" coefficient measures the adjustment speed of the endogenous variable towards the long-run equilibrium. The coefficient uncertainty is computed as the sum of the column vector of estimators and the error that is normally distributed, of null average and variance given by the covariance matrix of errors. If the estimations are replaced, the following model is obtained:

$$(\sum a_{1j}, \sum a_{2j}, \sum a_{3j}, v) = (\sum \hat{a}_{1j}, \sum \hat{a}_{2j}, \sum \hat{a}_{3j}, \hat{v}) + w,\ w \to N(0, \Sigma) \quad (7)$$

$$\varepsilon_t = -a_0 + (\Delta \log PIB_t - \sum a_{1j} \Delta \log PIB_{t-j}) -$$
$$- \sum a_{2j} \Delta \log ISD_{t-j} - \sum a_{3j} \Delta \log EXP_{t-j} - v \cdot EC_{t-1}$$

For testing the causality in Granger approach firstly the stationarity is checked using a unit root test like Augmented Dickey-Fuller (ADF), Phillips-Perron (PP) or KPSS. Johansen test is used for non-stationary series with at least one unit root. For co-integrated data series, VECM is used. VARD model is used only if a co-integration relation was not identified.

A. Identification of the integration order of the variables

ADF test (Augmented Dickey-Fuller) is used to check the stationary:

$$\Delta Y_t = \alpha_0 + \alpha_1 t + \alpha_2 Y_{t-1} + \sum_{i=1}^{k} \phi_i \Delta Y_{t-i} + aj_t$$

ΔY_{t-i} - logarithm of X in first difference (k lags)

aj_t - term for the adjustment of autocorrelation error

$H_0 : \alpha_2 = 0$ (non-stationary process, with unit root)

$H_0 : \alpha_2 < 0$ (stationary process)

Using a simple t test, the significance of α_2 is checked. The co-integration order is 1, if there is only a unit root.

An information criterion is used to determine the number of lags, Schwartz Information Criterion (SIC), that is the most suitable for small samples.

After the application of the ADF test, the conclusion was that the data series are not stationary, but all the data in the first difference were stationary for a level of significance of 5%. Thus, the integration order is 1.

B. The Johansen test

A linear relationship in the long run is checked between the variables with the same integration order. This is the co-integration condition and the null hypothesis of the Johansen test refers to the inexistence of the co-integration relationship between variables.

If X is a p-dimensional vector of non-stationary variables, then:

$$X_t = A_1 X_{t-1} + \ldots + A_k X_{t-k} + \varepsilon_t \,.$$

This relationship becomes:

$$\Delta X_t = \Gamma_1 \Delta X_{t-1} + \ldots + \Gamma_{k-1} \Delta X_{t-k-1} + \Pi X_{t-k} + \varepsilon_t$$

$$\Gamma_i = -[I - \sum_{i=1}^{k-1} \pi_i] \quad (8)$$

$$\Pi = -[I - \sum_{i=1}^{k} \pi_i]$$

Above we describe the matrices that include the information related to long-run relation when co-integration is accepted. There are 3 situations, according to Π degree:

r<p => r - number of co-integration vectors.

β - matrix of co-integration vectors and ϕ - matrix of adjusted coefficients => $\Pi = \phi\beta'$.

r=0 => Π - null matrix and there is no relationship on long-run => VARD model.

r=p => stationary variables.

Johansen test allows only for the identification of the number of co-integration relationships in the model. A value of λ_{stat} less than the critical value implies the inexistence of a co-integration relation between variables for a certain level of significance.

For stochastic variables with trend in the co-integrated regression, Johansen and Juselius (1990) showed that 3 assumptions should be tested: the spurious regression case when the variables are not co-integrated, the case of at most one co-integration relation and the case of at most 2 co-integration relationships. The two statistics are computed for each hypothesis: the statistic of maximal engine values and trace statistics, the values of both statistics indicating the same conclusion. The trace test was applied in EViews. In the table in ***Appendix 1*** we can observe only one co-integration relationship for a linear deterministic trend for 1%, and 5% level of significance.

The co-integration relationship obtained by normalising the coefficients indicates a positive dependence in the long run between GDP and FDI and GDP and exports: $\log PIB = 3.16 + 0.0137 \cdot \log EXP + 0.129 \cdot \log ISD$

C. The estimation of VECM model

A correction error model is estimated to reveal the causal relationships:

$$\Delta \log PIB_t = -0.234 \Delta \log PIB_{t-1} - 0.123 \Delta \log ISD_{t-1} + 0.062 \Delta \log EXPORT_{t-1} - $$
$$- 0.106(\log PIB_{t-1} - 0.0137 \log EXPORT_{t-1} - 0.129 \log ISD_{t-1} - 3.16)$$

The VEC model helps to maintain the equilibrium in the long run, existing a negative adjustment coefficient that, according to t test, is significantly different from zero. The error correction vector explains quarterly around 10.6% of the desequilibrium. The necessary period for reducing the gap between the actual GDP and the steady-state one (t) is computed as: $t = \frac{\ln(2)}{0.106} = 6.539$ quarters. Mathematically speaking, 13.078 quarters are necessary to reach the steady-state. In approximatively 14 quarters, till the second quarter of 2016, the GDP will reach the steady state, if productivity remains the same.

The results of the application of Granger causality procedure in EViews are described in ***Appendix 2***. As data are quarterly, the variant with 4 lags was chosen. The error correction model was built to show the causality between variables. The null hypothesis shows no causality relationship in Granger approach.

Therefore, the accuracy of GDP forecasts can be improved, if we consider the model with FDI and exports as causal variables. The results of parameter uncertainty assessment show a permanent shock in coefficients. The covariance matrix of errors has rather high values.

4. Conclusions

The evaluation of parameter uncertainty is an important goal for the policymakers. They should adapt their alternative policies to the predicted uncertainty. The economic shocks seldom affect the Romanian economy, the consequences being visible for the parameter stability.

In our country, a vector error correction model was built to reveal the impact of direct foreign investment and exports on the evolution of GDP. Indeed, a permanent shock to the parameters was measured during the period 2000-2012. The correction vector explains only around 10% of the disequilibrium. 14 quarters are necessary to bring the GDP in steady state, starting with the first quarter of 2013.

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APPENDICES

Appendix 1 - Trace test in Eviews

Trend assumption: Linear deterministic trend

Series: L_PIB_SA L_ISD_SA L_EXP_SA

Lags interval (in first differences): 1 to 1

Unrestricted Cointegration Rank Test

Hypothesized No. of CE(s)	Trace Statistic	5 Percent Critical Value	1 Percent Critical Value
None	41.09534	29.88	36.55
At most 1	4.032605	15.61	21.42
At most 2	0.047582	3.96	6.75

*(**) denotes rejection of the hypothesis at the 5%(1%) level

Trace test indicates 1 cointegration equation(s) at both 5% and 1% levels

Appendix 2 - The application of Granger procedure. Result description

Null hypothesis	F calculated	Prob.	Conclusions
logISD is not a Granger cause for logPIB	3.56478	0.020475	ISD influences the GDP. The GDP forecast is better if we take into account the direct foreign investments
logPIB is not a Granger cause for logISD	1.088	0.3737	logPIB is not a Granger cause for logISD
is not a Granger cause for logPIB	3.3886	0.02266	EXPORT influences the GDP
logPIB is not a Granger cause for logEXPORT	1.23536	0.30159	logPIB is not a Granger cause for logEXPORT
logISD is not a Granger cause for logEXPORT	0.44711	0.77809	logISD is not a Granger cause for logEXPORT
logEXPORT is not a Granger cause for logISD	2.2865	0.08274	logEXPORT is not a Granger cause for logISD