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VAR Methodology in Assessment of the Financial Stability

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ABSTRACT

Projecting a new operational framework designed to ensure the implementation of macro-prudential policy in order to ensure financial stability, it should start from developing the capacity of identifying and measuring the systemic risk, and ultimately, the level of financial instability being reached, early enough, to provide the due time for the macroprudential supervisory authorities to take the corresponding actions. This study investigates the possibility of constructing a composite index that serves to measure the evolution of financial stability and to explore this complex phenomenon in terms of identifying the causes that lead in this situation and the consolidation actions as well as to identify some macroeconomic variables which can be used in predicting the phenomenon. To measure the evolution of financial stability in Romania we used an aggregate index that consists of the fifteen variables which are able to capture the tensions between the different components of the financial system and between it and the real economy. Using the VAR methodology I marked out the influence of a good capitalization of the banking system on financial stability at the aggregate level, identifying and also quantifying the impact of some variables as the yield bonds or CDS quotes on financial stability and the possibility of their use in predicting the phenomenon.

1. Introduction

The severity of the effects of the 2007 global financial crisis and of the macroeconomic consequences felt heavily, both nationally and globally, there has been had initiated a comprehensive process of identification and development of new policies that should be able to respond appropriately to the challenges. As always over time, each shock felt on the economic level with serious effects on the economic activity in particular, but also on society as a whole, has become a challenge for the academicals world or for practitioners, to find explanations and solutions to overcome the dead end.

The recent global financial crisis is no exception to the ideas presented in the previous paragraph, and the novelty given, namely the macro-prudential policy, at the extent of the challenge, respectively, ensuring financial stability in a global economy and overfinancialised**.** The complexity of the financial stability can be designed, as shown by Schinasi (2007), as a *continuum*, a dynamic phenomenon that depends on the existing conditions at a given time, on the evolution of different components and connections between them, it raises particular problems in the steps taken to develop an appropriate working environment. Thus the macroprudential policy aims essentially to consolidate the financial system, primarily by gathering additional capital, designed to absorb the impact occurred, thus ensuring continuity of financial services and lending to the real economy.

Financial stability is therefore, a complex phenomenon determined and in turn determines the interdependence and mutual causal interconnections and studying the interconnections of different macroeconomic variables, of the mutual causality also of the impact of the past values of the variables on their current values can be achieved using the VAR methodology (Vector Autoregressions).

The present article aims at bringing its contribution to the development and improvement of the instruments used by the macro-prudential approach by studying the relationships and mutual interdependencies between the evolution of financial stability in Romania and various macroeconomic variables that influence and are influenced by that. To quantify the evolution of financial stability in Romania, I have used this aggregated index especially developed for the present purpose.

The work is structured as follows: Section 1 Introduction; Section 2 Literature Review; Section 3 Data and Methodology; Section 4 Results and discussion; Conclusion

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2. Literature review

VAR models represent a strong and flexible class of important instruments to describe and understand the macroeconomic phenomena, the relationships and interdependencies between different macroeconomic variables and to come up with credible forecasts. Among the important objectives of a macroeconomic analysis are of course, in addition to understanding phenomena and making predictions about them, providing solutions for policy development, these models being influential in this regard.

To measure the financial stress in the European Union or for any other comparable economics, Paries et al. (2013) develops a composite index whose structure is based on the method used by Illing and Liu (2003). Using this composite index that quantifies the level of the financial stress, the authors assess a VAR model that helps in studying the connection between the financial stability and the real economy. It is estimated the actual impact of the shocks of the financial system on the real economy, respectively, the shock on the credit supply for the European economy.

Miyajima et al. (2012) used the respective model to study the relationship between the financial stability and the development level of the local securities' titles in the emergent countries. The authors point out how important the local securities' titles and liquid market are, being capable to absorb the interior or exterior shocks, for the financial stability studying, helped by the VAR model, the government securities yield variation to various economic shocks suffered by the economies in question.

The relationship between financial stability and other variables such as return on government bonds and CDS quotations have been highlighted by other studies in the literature. Gyntelberg et al. (2013) confirms, based on this assumption, the close link between the spread of government securities, CDS spread quotations and the country risk assigned to every country by the investors, respectively, the financial stability. The existing link between the CDS spread, the spread of government securities and the information they provide about financial stability is studied by Mihai and Neagu (2011) who show that in the case of Romania, the evolution of the spread is determined, on a larger extent, by the global/ regional systemic risk and by the liquidity risk and to a lesser extent by the specific risk.

Nier et al. (2008) addresse the issue of proper capitalization of the banking system and the impact on the financial stability from a macroprudential perspective. The authors conclude that there is a direct connection between the level of the aggregate capital of the entire banking system and the probability of bankruptcy of the banks into the system. The low level of the aggregate capital weakens its resilience capacity, seen as a whole, by amplifying the systemic risk and the contagion effect.

Finally another study using a VAR model is made by Drehmann et al. (2005), who studies the impact of macroeconomic shocks on the companies' bankruptcies using as variables to characterize the macroeconomic conditions the GDP growth, inflation and interest rates.

3. Data and methodology

The data used was observed on a quarterly basis and was collected from authorized informants as follows: for data representing values of some aggregated indicators of the banking system, interest rates, foreign direct investment, etc. the informant is NBR, for variables as the budget deficit, the public debt, the authorized data provider was the Ministry of Finance and / or the National Statistics Institute, for market capitalization Bucharest Stock Exchange and some, like the ones in the category of spreads or those established as shares in GDP, for example, in this case, they were determined as the result of some calculations and data acquisition of the author. For the Eurozone, the data used was provided by Eurostat and the European Central Bank.

The variables' observation period was December 1996 - December 2012, following through this long time space the relevance increase as well as capturing important events that affected the Romanian economy, posted in the literature, such as economic and banking crisis since 1997 – 1999, financial crisis of 2007-2008 and Romania's adherence to EU (2006).

The methodology proposed by Stock and Watson (2001) which is used in the present article, indicates that VAR analysis is focused on deriving three categories of results: Granger causality, impulse response function and variance decomposition. Granger causality offers information about the capacity of a variable to foresee the other one, the impulse response function aims at following the effect on a variable on its present and future values as well as of the other variables in the system, and the variance decomposition indicates the relative importance of every shock regarding the generated effects on the variables in the system.

VAR is a methodology that is suitable for macro-prudential approach and that, assuming all variables' endogeneity, it shapes them all together. Models of this type are mainly used for studying the shocks (innovations) impact on the system of variables. The analysis involves studying the impact the shocks have on a variable, supported by the variable itself and the other variables.

A VAR (p) model may be represented like this:

$$Y_t = A_1 Y_{t-1} + A_2 Y_{t-2} + \cdots + A_p Y_{t-p} + BX_t + \varepsilon_t \quad (1)$$

Where:

Y_t - vector of endogenous variables
X_t - vector of exogenous variables
A_p,B -parameters to be estimated
ε_t -innovations

The application of this methodology can be achieved only if two conditions are fulfilled: the series used to be non-stationary and there is a cointegration relationship between them. Consequently, the first stage of the methodology involves testing the stationarity of the series and the results obtained as the result of the application of the augmented Dickey-Fuller test, confirming the fact that all of them are non-stationary. The next step was to test the existence of cointegration, using the MacKinnon- Haug-Michelis (1999) methodology that at a statistically significant level of 5% indicates a number of two cointegrating relationships.

The concept of cointegration means that two non-stationary series are cointegrated on the condition there is a linear combination of them for which the error's series is stationary. Hence, the equation in which the variables are non-stationary although the errors are stationary, is a co integration equation. Two variables that move non-stationary but in which case there is a linear stationary combination will have the tendency to go back to a balance state after a shock suffered, in other words, the economic concept of cointegration superpose with the concept of balance on long term, because the two exposed variables to the same fundamental factor that has specific effect upon them, will get adjusted to a relative balance on long term.

The results of the both tests carried out, attesting the non-stationarity of the existing series and the existence of the cointegration, validates the use of this method and authorizes the rating of a VAR with the variables formulated on levels.

Endogenous variables included into the model are: CDS spread Romania - Germany (S_CDS_RO_GE), yield spread of the government bonds Romania EU (S_TS_RO_EU) and the variation of the aggregated capital in the Romanian banking system (VFP_T). The model was estimated with two lags given test results carried out regarding their significance, showing that it is an optimal number if one takes into account the relatively small number of observations.

Considering the financial stability, as it has been shown in the introduction, this was quantified by a composite index: Financial Stability Index for Romania (ISFR), being produced according to the methodology recommended by the literature. The detailed presentation on the methodology applied to produce the aggregated index is the subject of another study as the author (Bors, 2015), so that, for the present work, I will only make a short description.

The macroprudential approach that stresses the connections and the mutual influences among different components (sectors) of the local economic system as well as among different economic systems at the global level, encourages the use of an aggregated index as a measurement instrument that can capture these interdependencies adequately (Jose and Georgiu, 2009). The methodology of producing an aggregated index to measure financial stability arises, according to the literature (Illing and Liu, 2003; Gersl and Hermanek, 2006; Cardarelli, Elekdag and Lall, 2009; Gadanecz and Jayram, 2009; Albulescu, 2010; Drehman, Borio and Tsatsaronis, 2011; Hollo, Kremer and Lo Duca, 2012; Paries, Maurin and Moccero, 2014), two important issues: *deciding on the variables and the aggregation method used.*

For the present work I chose to include 15 variables in the index (Annex 1), whose selection was made starting from the definition given to the financial stability and their ability to capture the existing tensions among the components of the financial system. The methodology used involves the aggregation of data before turning to a prior processing which consists of a normalization procedure, ie, relining values observed according to the benchmark values on an interval ranging from 0 to 1 in which, the observed value of a variable indicating a positive effect on financial stability as it is closer to 1 and, of course, tends to 0 when negative.

Their aggregation has been performed by granting the variables equal weights, this being the most widely used method (Gadacnez and Jayram, 2009), calculation using the following equation:

$$I_t = \sum_{i=1}^{r} g_i \times x_{i,t} \quad (2)$$

where:

I_t – The aggregated index at time t
$x_{i,t}$ – The variable x at time t (variable value obtained by the rebase using normalization procedure)
g_i – The weight assigned to the variable (equal weight; $g_i=1/r$)
r – The total number of variables

Further, in Table 1, the estimated model using formula (1) as described above:

Table 1 VAR model estimation

Regressors	***Dependent variable***		
	S_CDS_RO_GE	**S_TS_RO_EU**	**VFP_T**
$S\_CDS\_RO\_DE_{t-1}$	0.5141	-0.0130	-3.03E-05
	-0.1880	-0.0055	-7.00E-05
	[2.7335]	**[-2.3414]**	[-0.4314]
$S\_CDS\_RO\_DE_{t-2}$	-0.3883	0.0067	-1.62E-05
	-0.1453	-0.0043	-5.40E-05
	[-2.6717]	[1.5533]	[-0.2980]
$S\_TS\_RO\_EU_{t-1}$	2.3778	0.4842	-5.25E-03
	-5.2454	-0.1560	-1.96E-03
	[0.4533]	**[3.1040]**	**[-2.6769]**
$S\_TS\_RO\_EU_{t-2}$	3.4476	0.4137	7.78E-03
	-5.5204	-0.1642	-2.06E-03
	[0.6245]	**[2.5197]**	**[3.7702]**
VFP_T_{t-1}	567.1551	19.5957	0.9834
	-420.3950	-12.5038	-0.1572
	[1.3491]	[1.5671]	**[6.2553]**
VFP_T_{t-2}	-124.1613	-8.4975	-0.0944
	-445.4150	-13.2480	-0.1665
	[-0.2787]	[-0.6414]	[-0.5671]
C	1153.142	13.6107	0.0231
	-269.0390	-8.0020	-0.1006
	[4.2861]	**[1.7009]**	[0.2299]
$ISFR_t$	-2037.9550	-28.6396	0.0251
	-632.971	-18.8264	-0.2367
	[-3.2196]	[-1.5212]	[0.1063]
No. of observations	36	36	36
R-squared	0.8527	0.7198	0.9485
Adj. R-squared	0.8159	0.6498	0.9356

Note: *t-statistics* in parenthesis*;* significance level is 10%;
Sources: author's calculations

4. Results and discussion

Granger causality analyzes every variable's capacity to help predict other variables. The test results are shown in Table 2 below:

Table 2 Granger causality test results

Dependent variable / Regressors	***S_CDS_RO_GE***	***S_TS_RO_EU***	***VFP_T***
S_TS_RO_EU	0.5106		
VFP_T	0.2675		
All	0.5383		
S_CDS_RO_GE		**0.0571**	
VFP_T		0.2430	
All		0.1437	
S_CDS_RO_GE			0.7725
S_TS_RO_EU			**0.0007**
All			**0.0041**

Note: the ***p-values*** are shown in the table
Sources: author's calculations

Analyzing the reported values of this test it can be seen that for a significance level of 5%, CDS quotations help in predicting the yield of government securities (*p*-value is 0.0571), but not the capital variation. The yield on government securities helps to predict the variation in capital, the reported *p*-value being of 0.0007, while the CDS quotations do not help, instead, both can help predict the variation of capital (*p*-value is 0.0041).

Impulse response function describes the effect of a shock suffered by a variable on current and future values of the variable itself as well as on other variables in the system. The important issues to be pursued if the shock response function are: the sign of the effect, time level and the effects' persistence.

In *Annex 2* row one is shown responses S_CDS_RO_GE to shocks caused by the own value, by the bonds (S_TS_RO_EU) and by the aggregate capital movement (VFP_T), on row two are shown responses S_TS_RO_EU to shocks caused by the own value and the other two variables, and on row three the responses VFP_T to the shocks received similarly, responses from their own value as well as of the other two.

When analyzing the response S_CDS_RO_GE, it can be observed that this variable gives a positive response to its own shocks during the first three quarters, whereupon, the response is negative for the following two quarters and then starting from the sixth quarter to register a positive response again. As regards responses to CDS bonds and capital, movement they are both positive.

The S_TS_RO_EU responses is positive in the first quarter to the CDS shocks, negative in the second quarter, for the third to be positive again. The response to their own shocks as coming from the variation in the capital are positive.

The aggregated capital gives a positive response to their own shocks as well as to the CDS shocks, as regarding the government bonds the response is negative during the first three quarters whereupon it becomes positive again.

Variance decomposition provides a hierarchy of the effects of each shock on each variable, calculating the extent to which variation is caused by each shock (in percent of total), the results are being presented in *Annex 3*.

Analyzing the variation decomposing for S_CDS_RO_GE it can be observed that it is explained in 80% of the own innovations, indicating that during the first two quarters the personal contribution is of 100%. The contribution of the aggregated capital goes up to 20% and is growing at the end of the interval, while the S_TS_RO_EU brings an insignificant contribution during the first part of the interval (goes towards 0), registering a slight appreciation at the end.

S_TS_RO_GE variation is determined in its own turn by 90% in the first quarter by its own innovations following to contribute by 80% latter on. The innovations in CDS explain the S_TS_RO_GE variation in the proportion of about 10% throughout the period and aggregate capital innovations contribute to 0% in the first quarter and would later grow reaching 10% contribution.

Finally, the variation of the aggregated capital is explained in the ratio of 75-80% of its own innovations. CDS innovations in the first quarter explain a fluctuation in the capital in the ratio of 20%, as later their contribution to fall to 10%. Starting from the second quarter, innovations in S_TS_RO_GE bring their contribution to 15-20% to the capital fluctuation.

5. Conclusions

Taking decisions or policies implementation regarding the ensuring and maintaining of the financial stability, asks for some adequate instruments of measuring the level and the stability evolution so that they can identify the best actions to be taken, the instruments they need to use also to quantify the efforts and the results achieved.

In the present study, I investigated the possibility of quantifying the evolution of financial stability with an aggregate index able to capture the complexity of the phenomenon and the many connections and interrelations of the various factors that influence or which stability is influenced. The research results indicate the importance capitalization has at the aggregated level of the banking system in ensuring financial stability and there were identified, using VAR methodology, two variables, ie CDS quotations and the yield of the government securities, which can provide relevant information about the evolution of financial stability, which can be used to shaping and sizing/calibrating the applied policies.

Thus, synthesizing the results, we can see that both the yield on government securities and CDS quotes may indicate in advance the fluctuation of the aggregated capital in the banking system and all together help at predicting the financial stability. The impulse response function shows that if one considers the security interval, it is only the effects of their own innovations that are statistically significant for the three variables, and only for a period of 4-5 quarters. In terms of fluctuation of each variable analyzed it can be seen that on short term, it is determined on over 80% of their own innovations, as for the long-term to increase the shocks contribution of other shocks suffered by the other variables.

The research results confirm the role of the banking system's capitalization as an important pillar in supporting financial stability and the impact it has on the macroeconomic context. Certainly, as with other instruments of measuring financial stability, this type of techniques used in the study should be regarded as a toolbox that has its own limits, but it may be included in broader set of tools of macro-prudential approach,

providing the most adequate means of understanding some complex phenomena such as financial stability, and of calibration or development of the macroeconomic policies needed to be implemented to promote stability.

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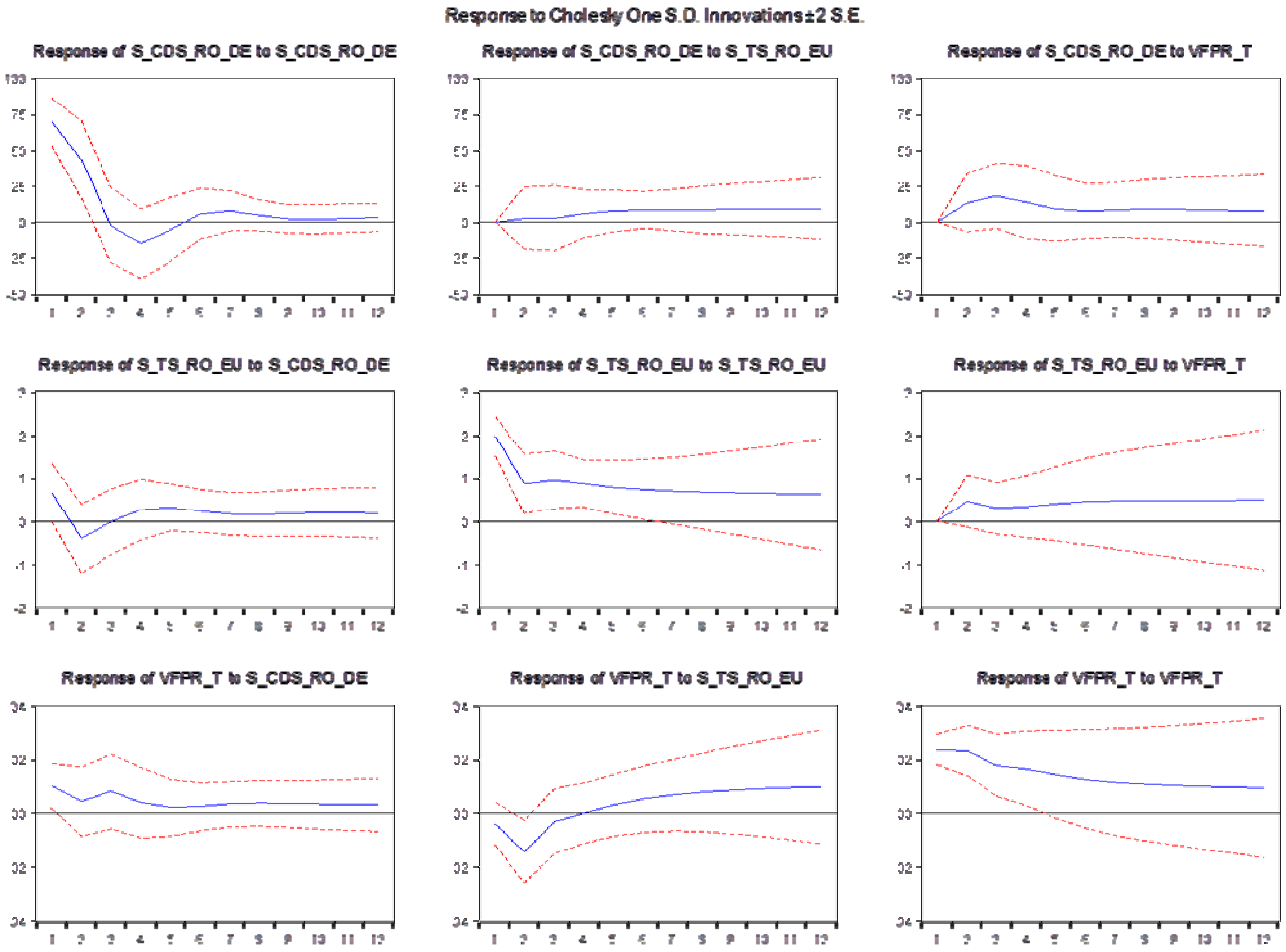
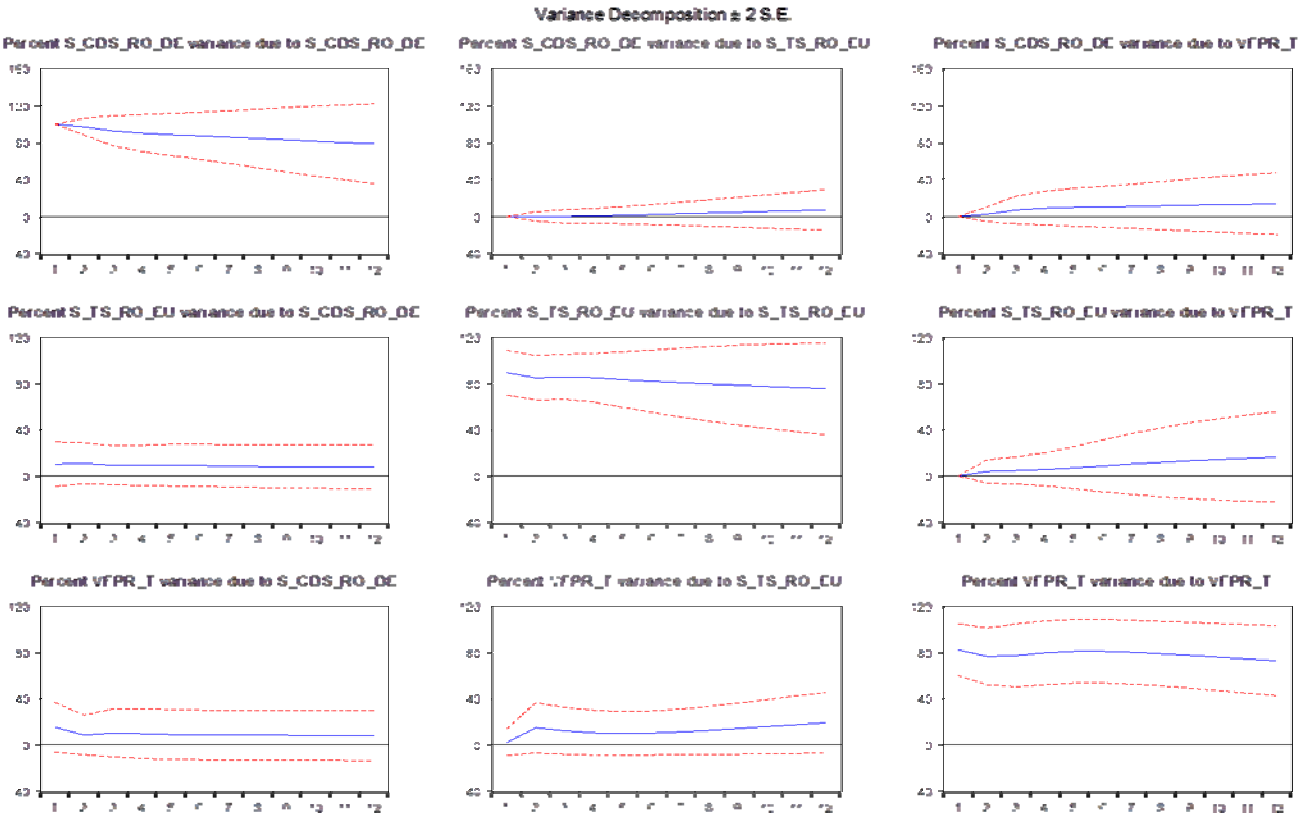
Annex 1

Sectors	Variable	Frequency	Codification
Banking system	Capital adequacy ratio (Solvability)	Q	IS
	Leverage ratio	Q	IEP
	Credit risk rate	Q	IRRC
	Loans to deposits ratio	Q	ICADA
	ROA	Q	IROA
Real Economy	Consumer Price Index	Q	IPC
	GDP growth	Q	IPIB
	Public Debt	Q	IDP
	Current Account Deficit	Q	IDCC
	Government Deficit	Q	IDB
Financial Market Development	Banking Intermediation Rate	Q	IGIB
	Market Capitalization	Q	ICB
	Foreign Direct Investments	Q	IISD
	The Interbanking Lending _Interest Facility spreads	Q	IED_FC_ROBOR
	The Rate of Interest Loans_Deposits spreads	Q	IED_CD

Annex 2




Variance Decomposition ± 2 S.E.
Percent S_COS_RO_DE variance due to S_COS_RO_DE
Percent S_COS_RO_DE variance due to S_TS_RO_EU
Percent S_COS_RO_DE variance due to VFPR_T
Percent S_TS_RO_EU variance due to S_COS_RO_DE
Percent S_TS_RO_EU variance due to S_TS_RO_EU
Percent S_TS_RO_EU variance due to VFPR_T
Percent VFPR_T variance due to S_COS_RO_DE
Percent VFPR_T variance due to S_TS_RO_EU
Percent VFPR_T variance due to VFPR_T