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Full Length Research Paper

The relationship between interest rates and sovereign ratings: An analysis using a Markov-switching model

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In this paper, the correlation between the evolution of credits' interest rate and sovereign rating was analysed. In order to capture this view, a Markov-switching approach was engaged to model the transition probabilities of low and high volatility regimes for interest rate. Also, the official rate of inflation and the amount of domestic credit denominated in lei were used as explanatory variables. The results of vector autoregressive approach revealed interesting interactions between the three macro variables, with interest rate being explained by both inflation rate and domestic credit. For the fact that the sovereign rating denotes a qualitative measure provided without a regular frequency, but which incorporates some subjective aspects, it was proposed as an indicator function to account for the sovereign ratings downgrades. Thus, to observe the relation between interest rate and sovereign rating, the transition probabilities of switching regimes for interest rate with the values of the indicator function mentioned before was correlated.

Key words: Markov-switching model, VAR, indicator function, rating, credits' interest rate, inflation rate, domestic credit.

INTRODUCTION

Sovereign ratings denote the assessment of relative likelihood for default. The rating agencies measure the risk of default by analyzing a wide range of variables such as repay of the debt, socio-political factors and others (Standard and Poor, 2008). Credit growth has been accompanied by developments with potentially negative effects on macroeconomic and financial stability, for example, current account deficits have grown, banks have turned to external resources, and inflationary pressures on the exchange rate have increased the debt population. Countries with the lowest per capita incomes recorded the fastest growth rates of credit. To capture the distinct dynamics of credit accelerated, some agencies have adjusted the calculation methodology by including country risk indicator credit speed. Two basic mechanisms are proposed for the explanation of the monetary policy transmission taking into account the heterogeneities in a credit market: the bank lending channel and a broader financial-accelerator mechanism. The bank lending channel assumes that banks' credits remain the dominant source of financing for small and medium-sized firms, whereas large firms can directly access the credit market issuing corporate securities like stocks and bonds. "The schematic diagram for the bank lending channel (F.S. Mishkin, NBER, Cambridge, USA, working paper 5464) showed that the contraction in money supply decreases the volume of bank deposits, which cannot be replaced by banks with other sources of funds." Therefore, some borrowers would be cut off from credits, thus increasing the external finance premium and this fact could create an impact on the reduction of both investments and the real sector.

The balance sheet channel also known as financial accelerator mechanism explains the effects of using three diagrams, underlining different ways of the transmission of monetary policy through the channel. Therefore, in this paper, this channel was followed to provide a post factum view about the relationship between the transition's regimes of interest rates (which is random) and the evolution of sovereign rating that has an irregular frequency and also incorporates subjective aspects.

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Tight monetary policy weakens the borrowers' balance sheets in several ways: the main one refers to the financial position of a firm (by diminishing the value of the borrower's collateral and the value of the firm's net worth), while others underline an increase in interest expenses (supposing that a firm has floating-rate or short-term debts). The adverse problem arises, when the drop in the net worth causes higher losses by adverse selection for lenders; this shrinks lending. The drop in the net worth of firms also makes owners with more incentives to engage themselves in risky investment projects, which are referred to as being a moral hazard problem. The real interest had an impact on the financial position of bank customers which is positive for the active interest rate, but negative on the level of liability. The lower yields for population's savings to banks provides an appropriate explanation for the modest increase in savings rates up to 2006. Another explanation is related to the credit demand, which is particularly higher on the same period.

In this paper, the correlation between the evolution of credits' interest rate and sovereign rating was analysed. In order to capture this view, a Markov-switching approach (H-M. Krolzig, University of Kent, UK, unpublished academic paper) was engaged to model the transition probabilities of low and high volatility regimes for interest rate. In the first part, the main econometric approaches engaged in the paper was described in order to analyze the triggers of sovereign rating, focusing on the specification of Value (VAR) approach and Markov switching model. In the empirical section of this paper, the Romania's sovereign ratings and the relationship between the migration of classes and the following macroeconomic variables were analyzed: domestic credit, interest rate and inflation rate.

LITERATURE REVIEW

A central topic of debate in macroeconomics remains the mechanism by which monetary policy is transmitted to the real economy. The bank lending channel can be summarized as the impact of the monetary policy on the amount and conditions of credit supplied by the banking sector. In recent years, bank lending has been a very important topic for research, especially as it is exemplified in Bernanke and Blinder (1992), who observed strong correlations among bank loans, unemployment and other macro indicators. Reisen and von Maltzan[1] (1999) analyzed the relationship between sovereign credit ratings and dollar bond's yield spreads. In order to find out if changes in ratings are mutually independent with changes in bond yields, they engaged a Granger Causality test.

A number of researchers have estimated the determinants of credit ratings for both mature and emerging markets, such as the GDP per capita, inflation rate and others, while Haque et al. (1996) showed that for developing countries, two other variables affect ratings and these are the interest rate and the structure of the exports. Juttner and McCarthy (2000) (Macquarie University Sydney, Australia, unpublished academic paper) studied the Asian crisis and found that the following variables were significant in explaining the turmoil: consumer price index (CPI), differential interest rate and the real exchange rate. Prior to the Asian crisis, the differential interest rate was not significant, indicating the fact that this variable may have not been included in the rating agencies models before the crisis.

Most of the analyzed time series in economic activity exhibit some breaks in their evolution at different moments of time. These break points are characterized by some abrupt changes of their behaviour. As an example from the literature, the analysis of dramatic changes in government policy (Hamilton, 1988) or the occurrence of some extreme events such as the crisis (Hamilton, 2005) can be mentioned. However, empirical evidences suggest in this sense that in periods of economic or financial activity with turmoil, some abrupt changes of time series' evolution are recorded, but we are not able to define a law that describes the features of these break points and also cannot suppose any downturns of the economy coinciding with the occurrence of some abrupt changes.

Markov switching model was first introduced in economics by Goldfeld and Quandt (1973) in order to capture the abrupt changes of time series in the presence of some break points. Cosslett and Lee (1985) first calculated the likelihood function for the Markov switching model in order to obtain the transition probabilities, but the model was widely popularized by Hamilton (1989) who initially used an iterative algorithm, and Engel and Hamilton (1990) who later used this kind of regression to analyze the business cycle and break points that occurred in the evolution of exchange rates.

METHODOLOGY

For a set of n time series variables $y_t = (y_{1t}, y_{2t}, ... y_{nt})'$, a VAR model of order p (VAR (p)) can be written as:

$$y_t = A_1 y_{t-1} + A_2 y_{t-2} + ... + A_p y_{t-p} + u_t \quad (1)$$

where the As are (n x n) coefficient matrices and $u_t = (u_{1t}, u_{2t}, ... u_{nt})$ is an unobservable iid[2] zero mean error term. Having the standard VAR (J.F. Rubio-Ramírez, T. Zha, Federal Reserve Bank of Atlanta, USA, working paper) as $X_t = A_0 + A_1 X_{t-1} + e_t$ and rewriting this as $X_t = \frac{A_0}{I - A_1 L} + \frac{e_t}{I - A_1 L}$, the stability of VAR approach requires that

[1] In their research authors used as method of estimation the logistic regression. Because the ratings are a qualitative ordinal measure other researchers used ordered probit estimation, for example Hu et al (2002).

[2] Independent and identical distributed random variables.

the roots of the $(I - A_1 L)$ that lie outside the unit circle[3]. This is a necessary and sufficient condition for stability.

The determination of lag length is important because if the lag length is too short, the autocorrelation of the error terms could lead to wrong results, but on the other hand, the small lag length requires a large number of parameters which decreases the number of degrees of freedom.

According to Granger causality, if a variable x "Granger-causes" (or "G-causes") other variable signal y, then past values of x should contain information that helps predict y above and beyond the information contained in the past values of y alone. Considering the fact that Granger-causality may not cover all the interactions between the variables of a system, further analysis should be performed often “to know the response of one variable to an impulse in another system’s variable” (Lutkephol, 1993).

The impulse response test account for the effects of an exogenous shock on the whole process over time. Another important tool used for the analysis of dynamic interactions between macroeconomic variables is the variance decomposition approach. The aim of the decomposition is to reduce the uncertainty in one equation to the variance of error terms in all equations. Empirical evidences showed that in periods with economic financial distress, some abrupt changes of time series’ evolution are observed, which facilitate the switching of different regimes in the related series. The transition probabilities from one state to another are random and not deterministic in order to predict the occurrence of abrupt changes. In these conditions, there can be a supposition that interest variable i_t follows a stochastic first-order autoregressive process:

$$i_t = c_1 + \phi i_{t-1} + \varepsilon_t \quad (2)$$

where, i_t is the interest rate, c_1 is a constant and $\varepsilon_t \approx N(0, \tau^2)$.

Supposing that at a certain moment in time, t_1 was recorded as an abrupt change in the evolution of the observed variable, it can be said that i_t shifted from one state to another, but this transition was determined by an abrupt change in one element of Equation (2). In order to account for this shift between states, the occurrence of a break point in the long average c_1 can be considered as an example. Thus, the new first-order autoregressive process of the variable will be:

$$i_t = c_2 + \phi i_{t-1} + \varepsilon_t \quad (3)$$

However, in the entire evolution of a variable, several transitions between states such as this one described before still exist. Therefore, it is not suitable to suppose that at a certain moment in time, Equation (2) governs the evolution of variable i_t and Equation (3) does same after this period. With these conditions, it is more appropriate to engage a canonical form of a first-order autoregressive process that covers a dynamic transition between different states:

$$i_t = c_{s_t} + \phi i_{t-1} + \varepsilon_t \quad (4)$$

where s_t denotes the switching of regimes. Thus, if only two regimes are considered in which the selected variable i_t can evolve, s_t represents a random variable that, for example, takes the value 1 when the time series is in the first state at the related moments of time, t=
1,2,3…, and takes 2 when i_t is in the second state for the other moments.

As it is previously mentioned, the transition between states is not directly observable, due to the fact that it is random. This fact emphasizes the need to formulate a probability law to define the switching of regimes. Thus, considering previously a Markov chain with only two states, the conditional probability that selected time series in one state can be formulated as:

$$\Pr(s_t = j | s_{t-1} = 1, s_{t-2} = k, ..., y_{t-1}, y_{t-2}, ...) = \Pr(s_t = j | s_{t-1} = i) = p_{ij} \quad (5)$$

With the following 2×2 transition probability matrix:

$$p = \begin{pmatrix} p_{11} & p_{21} \\ p_{12} & p_{22} \end{pmatrix} \quad (6)$$

The random aspect of transition between states occurred from the fact that even the variable i_t is directly observable, an indication that the state is done using an inference. In order to estimate the model, a joint distribution of i_t and s_t is used on past information:

$$f(i_t | \psi_{t-1}) = f(i_t | s_t, \psi_{t-1}) f(i_t | \psi_{t-1}) \quad (7)$$

where ψ_{t-1} include information at time t-1 and $f(i_t | s_t, \psi_{t-1})$ is the conditional normal density function for regime $s_t = j$. Weighting the density functions for the two regimes, the likelihood function estimated is:

$$\ln L = \sum_{m=1}^{T} \ln \left\{ \sum_{m=1}^{2} f(i_t | s_t, \psi_{t-1}) \Pr(s_t = j | \psi_{t-1}) \right\} \quad (8)$$

where $\Pr(s_t = j | \psi_{t-1})$ is a filtered probability in the spirit of Kalman Filter as Hamilton (2005) underlined:

$$\Pr(s_t = j | \psi_{t-1}) = \sum_{n=1}^{2} \Pr(s_t = j | s_{t-1} = i) \Pr(s_t = i | \psi_{t-1}) \quad (9)$$

The updated probabilities are calculated as follows:

$$\Pr(s_t = j | \psi_{t-1}) = \frac{f(i_t | s_t = j, \psi_{t-1}) \Pr(s_t = j | \psi_{t-1})}{\sum_{m=1}^{2} f(i_t | s_t = j, \psi_{t-1}) \Pr(s_t = j | \psi_{t-1})} \quad (10)$$

DATA AND EMPIRICAL RESULTS

The analyzed sample ranged from January 1996 to December 2006, where the domestic credit is denoted by the amount of public and private credit denominated in lei (interest rate is the credit’s interest rate) and also denominated in local currency. As such, the inflation series represents the official inflation rate of Romania, while the sovereign ratings are given by Standard and Poor (2008). The used date is on monthly basis, and it has sovereign rating which was not a regulated frequency. The sample used in this paper stopped at the of 2006, because starting

[3] This is similar to the idea that the roots of the $(I - A_1 L)$ lie inside the unit circle.

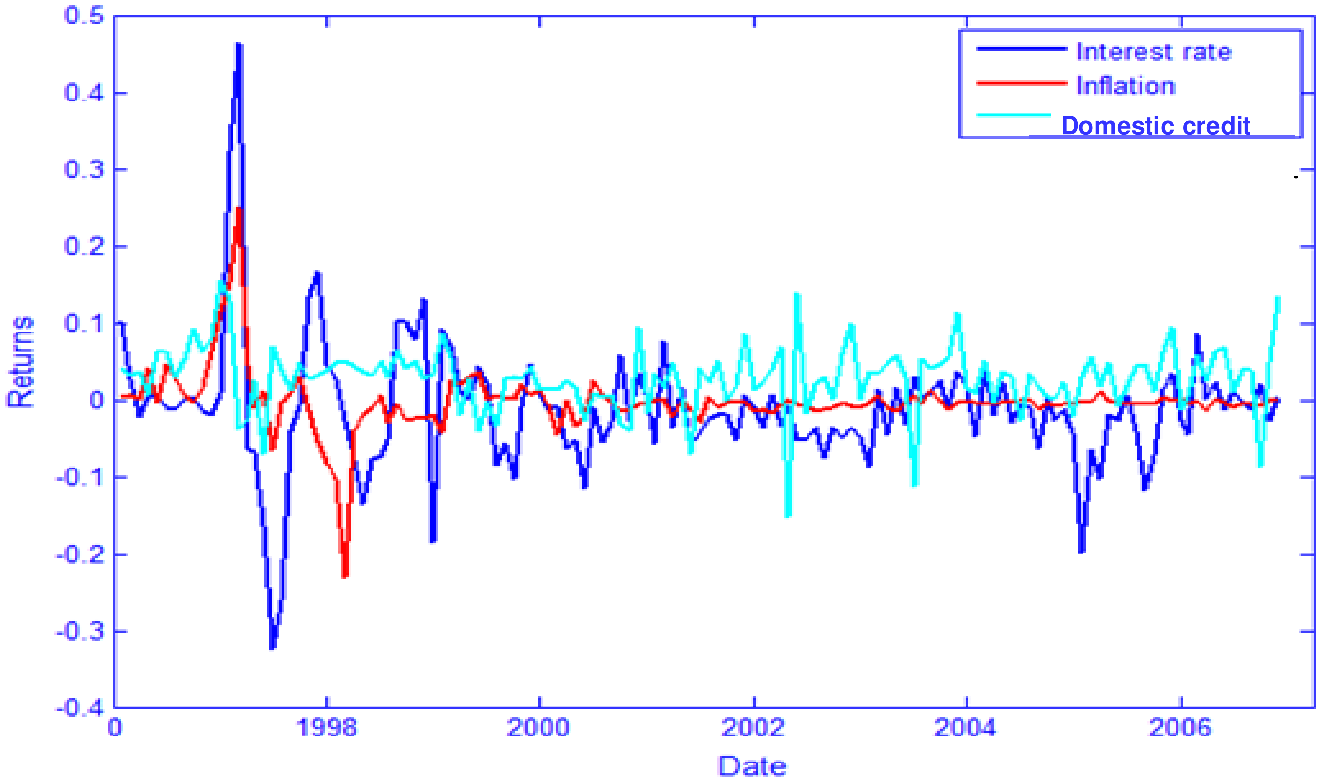

Figure 1. Evolution of returns of the variables used.

with 2007, the National Bank of Romania has modified the methodology for calculating the amount of domestic credit. The descriptive statistics revealed leptokurtic and negative skewed series for credit data and positive skewed series for the other two variables for the sample used (Annexes, Table 1).

In order to capture the relationship between interest rate and the evolution of Romania's sovereign rating, this paper focused on analyzing the evolution of the credit's interest rate of transition states. Thus, the interest rate of intern credit has been chosen as an endogenous variable because in the study's view, the credit's interest rate had an important impact on the evolution of credit and implicitly of business cycle due to its strong impact on the amount of both public and private investments. With these conditions, because the credit interest rate is an important driver of credit and business cycles, the switching of regimes was considered using an unobserved Markov chain of the credit's interest rate as proxy for the phases of credit cycle.

As the literature about Taylor's Rule opines that the monetary policy interest rate responds to shocks on inflation and output-gap, this paper considers the phases of credit cycles responses to changes in domestic credit and inflation, which denote the real and monetary sector of the economy, respectively. Therefore, the interest rate of domestic credit has been regressed on inflation and on the amount of domestic credit, including also a constant which denotes the long-time average of interest rate, while the residuals are Gaussian $(\varepsilon_t \approx N(0,\sigma^2))$. a switch of transition probabilities has been set on the constant and residuals, which means that c_{s_t} controls the switching dynamic of mean equation and ε_{s_t} controls the switching dynamic of residuals vector through $\sigma^2_{s_t}$. While the inflation rate and domestic credit are independent, as the hypothesis of regression theory requires, the unconditional dependence among the two variables mentioned before and the credit's interest rate is driven entirely by the unobserved state of the credit cycle. As the theoretical aspects, with regards to the methodology and Markov chains used here, are aperiodic and irreducible, the ergodic theorem means that the chains have a unique steady-state probability vector.

However, to correlate the transition between the states of the interest rate and the changes of sovereign rating which do not have a regular frequency and which incorporate subjective aspects related to the changes of ratings in one sense or another, an indicator function have been constructed here in order to account for the cutting-down of sovereign rating:

$$1_{Rating\ \ Status} = \begin{cases} 1, if\ the\ \ rating\ has\ been\ downgraded\ \ from\ the\ \ previous\ \ period \\ 0, if\ the\ \ rating\ has\ been\ upgraded\ or\ it\ remained\ \ cons\tan tly \end{cases} \quad (11)$$

The analyzed data series exhibited some unit roots as the stationary test have revealed, but the results of ADF test done on the related returns showed no unit roots (Annexes, Table 2). It can be noticed in some different behaviours in the evolution of returns and of their trends (Figure 1), underlining some high volatility in returns for inflation and interest rate ranging from 1996 to 1999. Also, the computation of cumulative distribution functions (CDF[4]) revealed very different degrees of asymmetry in both tails, with the interest rate posting the highest asymmetry in comparison with the standard Gaussian CDF (Annexes, Figure 2). This period was culminated with accentuated turmoil in financial, economic and political sectors. Firstly, the several bankruptcies of some Romanian banks surrounded by allegations of serious corruption facts, and then by both the weakness of adopted structural reforms and high depreciation of domestic currency created an enormous pressure on interest rate, additionally to the expectant inflation. However, with the descending evolution of interest rates, which was especially driven by the continuous and sound disinflation process, the domestic credit increased faster.

In order to analyze the relation between the three series of data, a VAR approach was engaged. The engaged model satisfies the stability condition since the modulus of roots are lower than 1. This means that the roots are inside the unit circle and this model could be considered as valid (Annexes, Table 3). The Granger causality test shows that inflation and interest rate does not cause the evolution of domestic credit, but the domestic credit causes both. Interest rate is Granger-caused by inflation, but does not cause inflation (Annexes, Table 7). The correlation matrix reveals the fact that a positive relationship exists between inflation and interest rate, while the value of 0.41 does not affect the study's analysis since there is no subject of multicollinearity (Annexes, Table 6). A set of preliminary test for residuals have been performed in order to have a model that is correctly estimated and there is no residual autocorrelation up to lag 4 since the null hypothesis of Portmanteau test for autocorrelations is accepted (Annexes, Table 4). Also, the serial correlation at lag 4 is rejected since p-value is higher than 1% (Annexes, Table 5). In addition, the variance decomposition analysis showed that the variance of domestic credit was explained by an endogenous evolution (Annexes, Figure 3). This fact was due to the convergence process of Romanian's economy in the analyzed period, in which a very fast growth was observed in foreign investments directly. Instead, the variance of the interest rate was explained in a proportion of almost 20% by domestic credit, while the influence of inflation was much lower. In the same time frame, the variance of inflation was explained in a more balanced mode by both domestic credit and inflation, but to obtain a deeper view of interaction among the three variables, an impulse-response analysis was engaged, in which positive shocks were defined on each of the three series analyzed.

As it can be observed (Annexes, Figure 4), the positive responses of interest rate and inflation to a positive shock on domestic credit, in a period of twelve months, occurred very rapidly and presented closely, degrees of persistence that converged asymptotically and almost simultaneously to zero, but the reaction of inflation to positive shock on domestic credit was less stronger than that of the interest rates. Instead, the response of domestic credit to a positive shock of interest rate is negative and not very strong (posting a very low persistence), while the response of inflation is more persistent and stronger. A very interesting remark is that the response of domestic credit to a positive shock on inflation is almost zero, while the response of interest rate exhibits a very high degree of persistence.

The results of the three engaged analysis included by the VAR approach permitted the study to obtain a more deeper picture of the relationship among the evolutions of the three series in the case of an emergent economy. Once the interactions between selected variables have been analyzed, a Markov-switching approach was used to observe the relationship between transition probabilities of interest rate and sovereign ratings' downgrades. In order to attain this task, the following regression was used:

$$i_t = c_{s_t} + \alpha\pi_t + \beta cr_t + \varepsilon_{s_t}$$

Where, i_t = interest rate, c = constant, α = inflation rate parameter, π_t = inflation rate, ß = domestic credit parameter, cr_t = domestic credit, ε = residual and s_t = state.

In Equation (12), the relation c_{s_t} controls the switching dynamic of the mean equation and ε_{s_t} controls the switching of the residual vector. The estimated parameters are significantly different from 0 as indicated by the p-values (Annexes, Table 8). The parameter of inflation

[4] Cumulative distribution probability was calculated using the Kaplan- Meier approach.

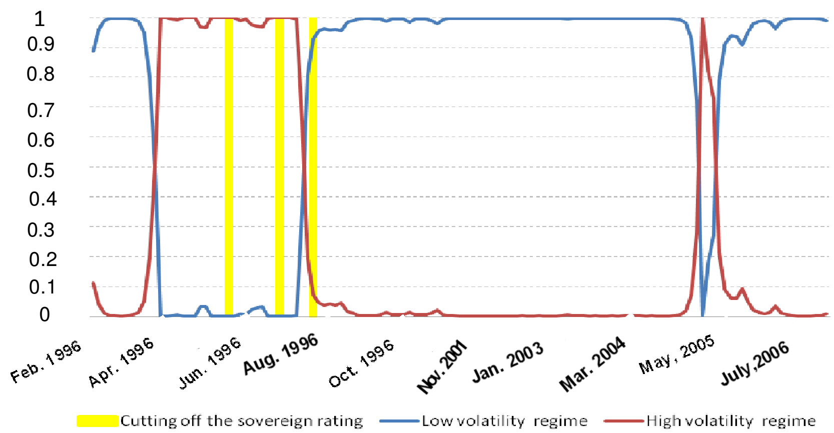

Figure 2. Markov switching regimes of interest rate.

rate, α, indicated a much higher explanatory power on the evolution of the interest rate regimes exhibited by the domestic credit's parameter, ß. These results could be explained by the fact that while the amount of domestic credit has recorded a faster growth only after 2002[5], the high levels of inflation during 1996 to 1999 posted an important impact on inflation volatility.

The higher value recorded by p_{11} through staying in a low volatility (0.98, significant at 5%) led to a significantly higher expected duration for the regime of low volatility. The explanation for this result could be the convergence process of the Romanian economy which coincided with a continuous decrease of the credit. Also, the transition of inflation rate to 1 digit levels has eased the pressure on the credit interest rate. It can be observed in Figure 2, as it is expected that the presence of a high volatility regime between the end of 1996 and the middle of 1999 culminated with 3 downgrades of the sovereign rating in this period. Also, in this period, the inflation rate has recorded the highest levels from the analysed period[6], which sustained the estimated results from Markov-switching regression (Annexes, Figures 5 and 6).

Thus, the high volatility regime of interest and high inflation rate during the end of 1996 and the end of 1997 preceded the first cut sovereign rating in January 2008. While the inflation came back to a descendent trend starting with February, the high volatility regime of interest rate continued to persist and two other cuts of sovereign rating in October 1998 and April 1999 were assisted up to B-. In the same time frame, the evolution of domestic credit was very smooth in the "hot period", when a high volatility regime and 3 several downgrades of sovereign rating were previously referred to.

[5] Reporting the amount of domestic credit at the end of 2001 on the beginning of '96, a ratio about 8 was obtained, showing a significant increase of this variable. But the same report in late 2006 indicated a value of 6 times greater, indicating an increase, this time exponentially.

[6] The peak value of inflation rate was recorded in June 1997.

DISCUSSION AND CONCLUSION

The three analyzed macroeconomic variables have recorded very different evolutions in the analyzed period. For this reason, the interactions were first analyzed between them. The results of an engaged VAR approach revealed that the evolution of amount of domestic credit is explained by an exogenous cause of Romanian economy, namely by the foreign direct investments. Instead, as the impulse-response showed us, the relation between inflation and interest rate exhibits some persistence in time. The results of Markov-switching model of regression confirmed a high explanatory power of inflation rate on the interest rate evolution. In addition, the results of Markov-switching model revealed a higher probability to staying in a low volatility regime of the interest rate which led to a significantly higher expected duration for the regime of low volatility. Instead, the short period of high volatility regime was culminated with 3 several downgrades of sovereign rating and with the highest levels of inflation rate from the study's sample. Thus, it can be concluded that during the period between the end of 1996 and middle 1999, the uncertainty generated by high volatility regime of interest rate could be considered as an *a priori* announcement for the 3 several cuts of sovereign rating.

Starting from the analyzed studies, the study's presented methodology underlines the introduction of the interest rate in models of sovereign rating. Considering the relation between interest rate and sovereign rating, the transition probabilities of switching regimes for interest rate were correlated with those values of the indicator function used for rating downgrades.

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ANNEXE

Table 1. Descriptive statistics.

Descriptive statistics	Credit	Inflation	Interest rate
Mean	0.0291	-0.0014	-0.0116
Median	0.0306	-0.0027	-0.0108
Maximum	0.1562	0.2510	0.4668
Minimum	-0.1515	-0.2312	-0.3253
Standard deviation	0.0437	0.0402	0.841
Skewness	-0.5781	0.9276	1.2811
Kurtosis	5.9204	23.2892	13.1582

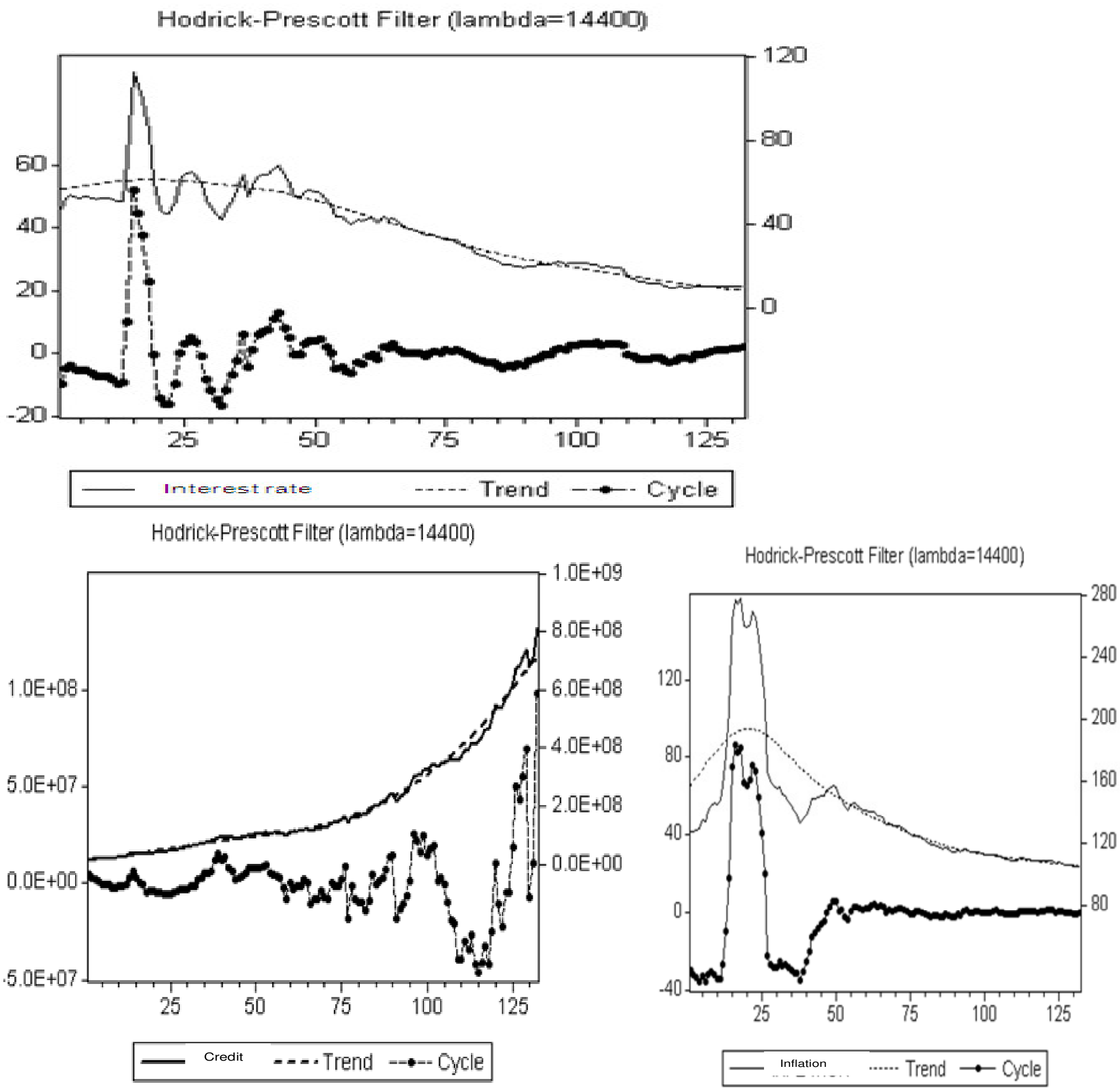

Figure 1. Estimation of trends and cycles using Hodrick Prescott Filter.

Table 2. ADF test *denotes rejection of null hypothesis at 1%.

Null hypothesis: Variable has a unit root		Credit		Inflation		Interest rate	
		t-Statistic	Prob.*	t-Statistic	Prob.*	t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-11.6253	0.0000	-5.6366	0.0000	-7.6598	0.0000
Test critical values (% Level):	1	-3.4812		-3.4861		-3.4825	
	5	-2.8838		-2.8859		-2.8843	
	10	-2.5787		-2.5798		-2.5790	

*MacKinnon (1996) one-sided p-values.

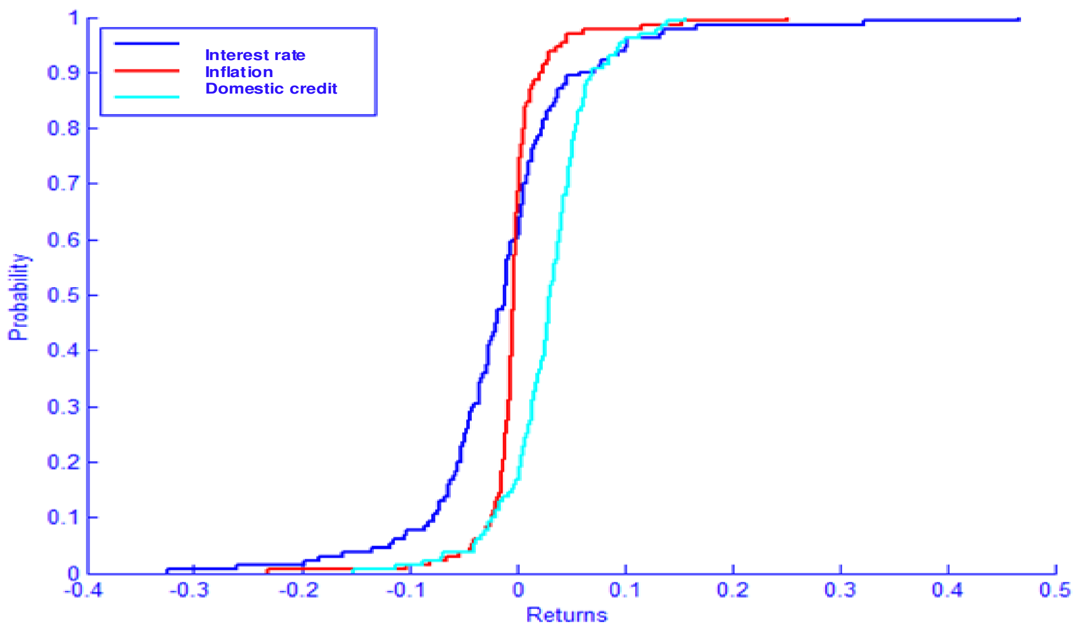

Figure 2. Cumulative distribution functions for the macro variables.

Table 3. Stability analysis of VAR.

Roots of characteristic polynomial			
Endogenous variable	**Exogenous variable**	**Root**	**Modulus**
Credit interest rate inflation	C	0.581278	0.581278
		0.320268	0.320268
		0.051444	0.051444

VAR satisfies the stability condition. No root lies outside the unit circle.

Table 4. Portmanteau autocorrelations test.

Null hypothesis: No residual autocorrelations up to lag h					
Lags	**Q-Stat**	**Prob.**	**Adj. Q-Stat**	**Prob.**	**df**
1	3.1258	NA*	3.1500	NA*	NA*
2	18.4030	0.3008	18.6659	0.2864	16
3	28.3310	0.2928	28.8284	0.2712	25
4	39.8393	0.2263	40.7021	0.1992	34

*The test is valid only for lags larger than the VAR lag order. df is the degree of freedom for (approximate) χ^2 distribution.

Table 5. ARCH-LM test (H_0: No serial correlation at lag order h)

Lags	LM-Stat	Prob.
1	12.6623	0.1785
2	17.1277	0.0468
3	10.6806	0.2982
4	12.0139	0.2125

Probs from chi-square with 9 df.

Table 6. Correlation matrix.

	Credit	Inflation	Interest rate
Credit	1.0000	-0.0045	0.0721
Inflation	-0.0045	1.0000	0.4182
Interest rate	0.0721	0.4182	1.0000

Table 7. Granger causality test.

Null hypothesis	F-Statistic	Prob.
Inflation does not Granger-cause credit	0.3309	0.5662
Credit does not Granger-cause inflation	13.7264	0.0003
interest rate does not Granger-cause credit	1.7352	0.1901
Credit does not Granger-cause interest rate	16.1254	0.0001
interest rate does not Granger-cause inflation	1.0564	0.3060
Inflation does not Granger-cause interest rate	3.0040	0.0855

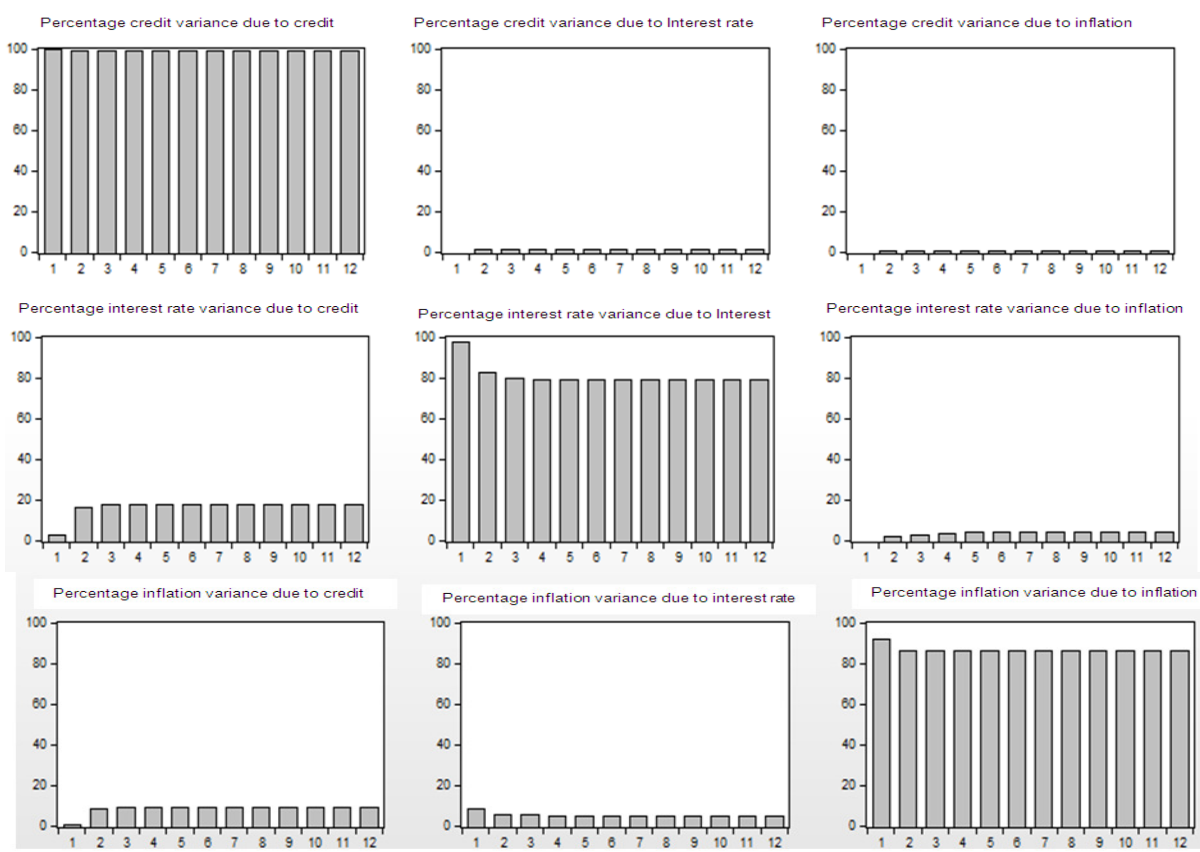

Figure 3. Variance decomposition.

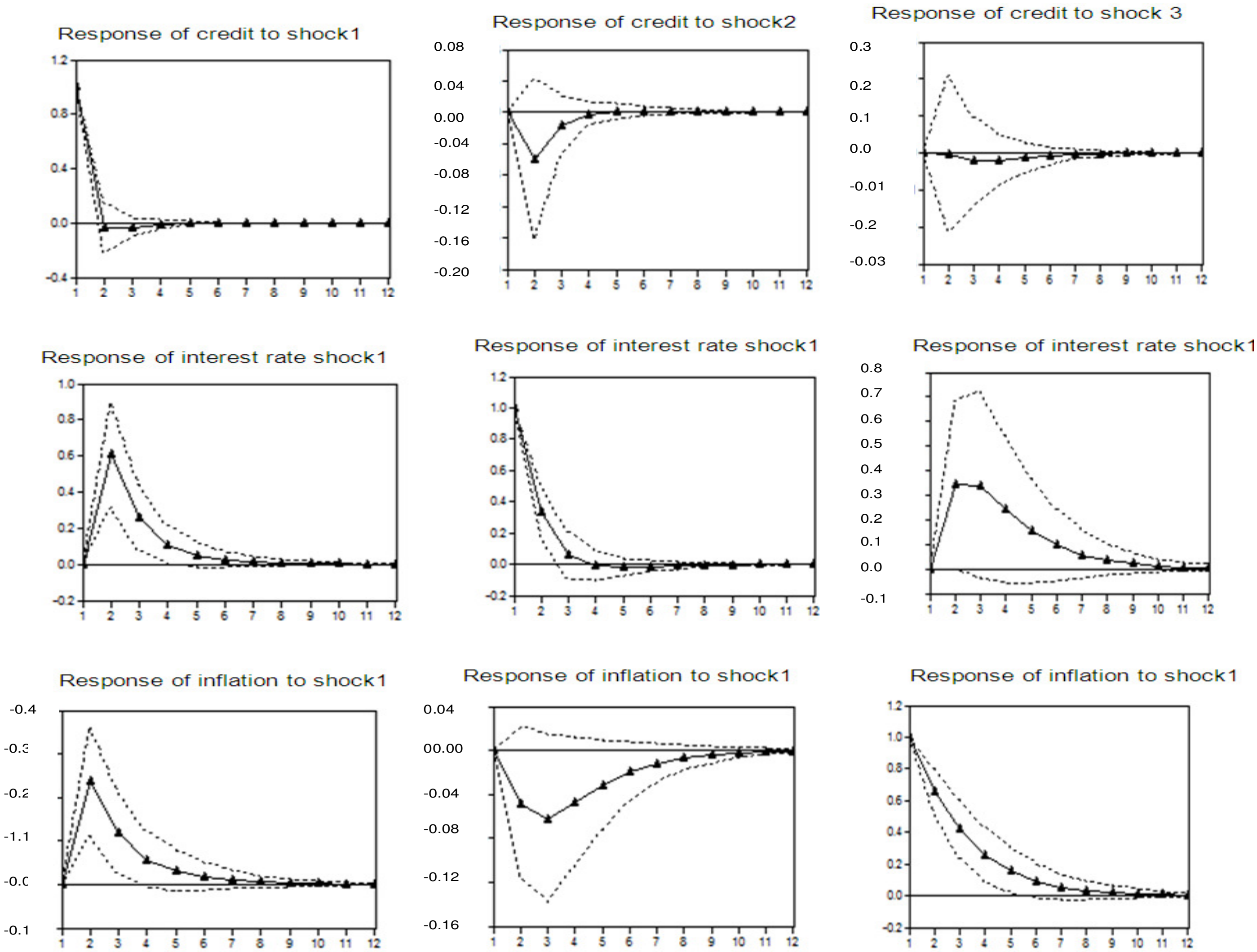

Figure 4. Impulse-response function to a positive shock on: (i) domestic credit; (ii) interest rate and (iii) inflation.

Table 8. Estimated coefficients of Markov-switching model.

Parameter	Markov-switching estimated coefficient
c_1	-0.0158 (0.00)
c_2	-0.0040 (0.00)
α	0.6158 (0.00)
β	0.0513 (0.00)
σ_1^2	0.001347 (0.00)
σ_2^2	0.020248 (0.00)
p_{11}	0.98 (0.02**)
p_{22}	0.92 (0.08***)
Expected duration of low volatility regime	42.22 time periods
Expected duration of high volatility regime	12.52 time periods
Log-likelihood	191.0371
AIC	-362,0742
BIC	-333,3223

**are significantly different from 0 at 5% confidence level, ***are significant different from 0 at 10% confidence level.

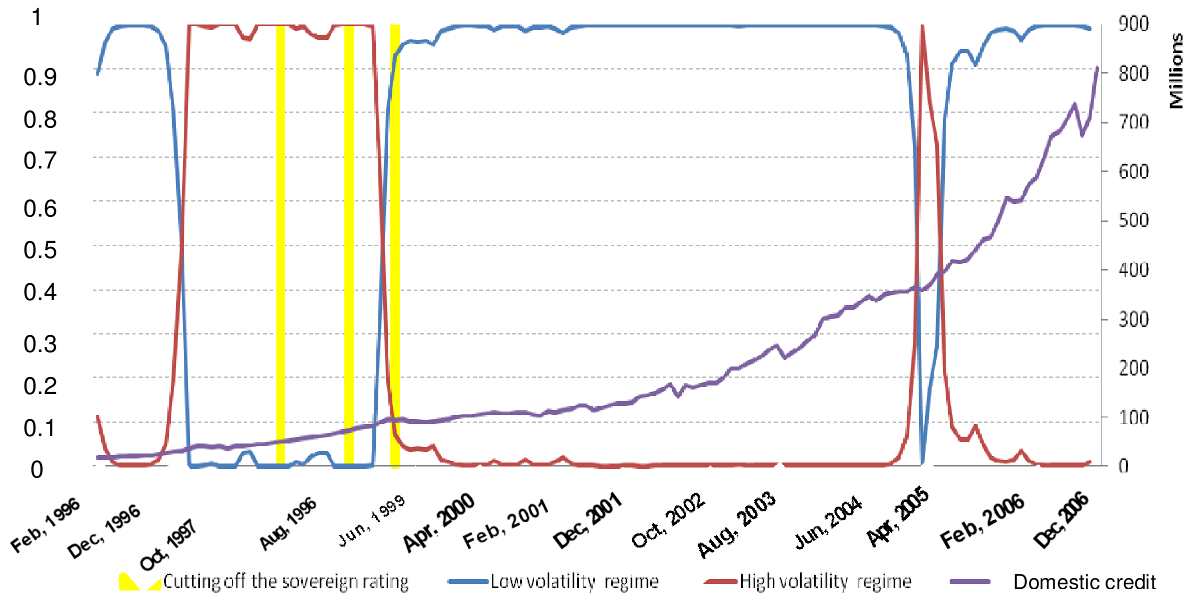

Figure 5. Markov switching regimes of interest rate and domestic credit.

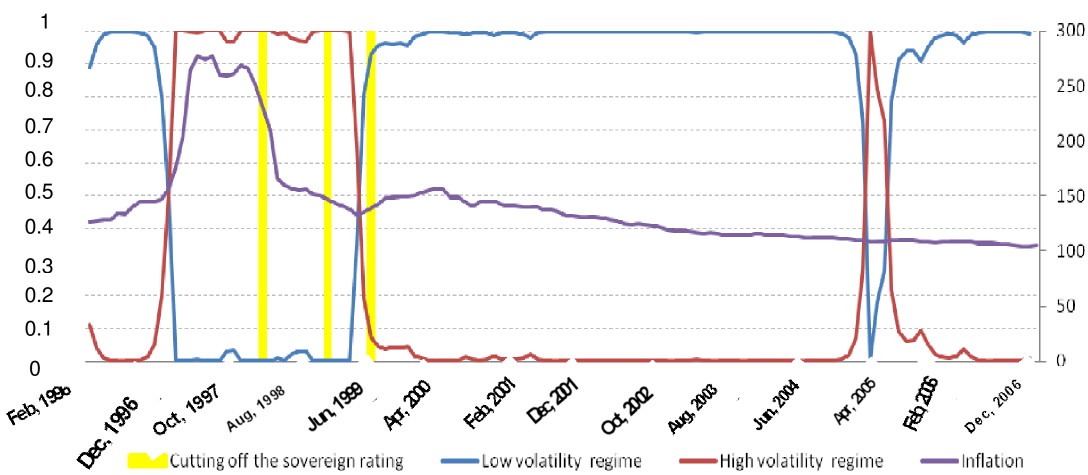

Figure 6. Markov switching regimes of interest rate and inflation rate.