Macroeconomic Variables and Stock Market Evolution

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Abstract
This study investigates the relationship between local and global macroeconomic factors and stock market indices in Romania using the framework of the macroeconomic APT model. Many researchers have demonstrated that macroeconomic conditions affect risk factors and influence asset returns. However, it is well-known that emerging markets’ asset returns are characterized by higher volatility than on developed markets. Using the stepwise analysis method we found some evidence of the effects of exchange rates, interest rates (global), gold price, global stock indices and oil prices on stock returns of the Bucharest Stock Exchange (BSE). We also investigate the effects of macroeconomic factors on the investment firm’s indices, BET-FI. The results of a Vector Autoregressive model (VAR) and Vector Error Correction Model (VECM) indicate the short and long run linkages between macroeconomic variables and BSE indices.

Key words: stock market index, arbitrage pricing theory, macroeconomic variables, VAR, interest rate

We will construct two APT models: the first will have BET returns as endogenous variable while the second will have BET-FI returns, both using monthly data for a nine year interval between June 2002 and May 2011. The macroeconomic variables were chosen as suggested by the literature review. As macroeconomic indicators with local impact we have selected the industrial production index (IPI), the wholesale price index (WPI), the consumer price index (CPI)\(^1\) and the nominal Romanian leu - euro exchange rate, the official interest rate, the interbank interest rate and M2\(^2\). As for macroeconomic data with global impact we have included the oil price (West Texas Intermediate)\(^3\), gold price\(^4\), short term 3-Month Treasury bill’s rate and long-term 10-year Treasury bond\(^5\). All data were denominated in euro and in the case of CPI we proceeded to a seasonal adjustment.

The main aim of our research is to develop an APT model and after that to investigate the dynamics of the variables using a VAR and VEC model, the latter in case if stock prices are cointegrated with macroeconomic variables.

As a first step we proceeded to establish and deal with possible collinearities between time series that would otherwise impact in the stepwise regression procedure. It was established a 0.94 significance level for the time series estimated as collinear, explicative collinear indicators excluding themselves.

\(^1\) National Statistics Institute [http://www.insse.ro]
\(^2\) Romanian National Central Bank [http://www.bnro.ro]
\(^3\) U.S. Energy Information Administration [http://www.eia.gov/]
\(^5\) Federal Reserve Economic Data [http://research.stlouisfed.org/fred2/]
Since the financial and macroeconomic time series are not stationary, they were firstly stationarized at I(1), as logarithm differences, and after that they were tested successfully for stationarity with ADF and PP tests at 5% significance level. Because returns of financial assets have conditional heteroscedasticity, PP tests are favoured for financial time series.

After these tests we have constructed the APT models as follows:

\[ DL_{BET} = F(x_1, x_2, x_3, \ldots, x_n) \]
\[ DL_{BETFI} = F(x_1, x_2, x_3, \ldots, x_n) \]

where \( DL_{BET} \) and \( DL_{BETFI} \) are the returns of BET and BETFI stock index and \( x_1, x_2, \ldots, x_n \) are the stationarized series of the macroeconomic data selected.

The APT model is estimated by a multivariate regression with \( n \) variables using the stepwise procedure available in Eviews 7. Stepwise regression is an automatic variable selection procedure which selects the best explanatory variables from a set of variables. The stepwise method starts with no variables in the regression and selects first the variable with the lowest \( p \)-value if it were included, then the variable with the second lowest \( p \)-value conditional upon the first variable already being included, and so on. The procedure continues until the next lowest \( p \)-value relative to those already included variables is larger than our specified threshold value, then the selection stops, with no more variables being incorporated into the model (Brooks, 2008).

The stepwise procedure was criticized on similar grounds to data mining procedure: the degree of correlation between the predictor variables affect the frequency with which authentic predictor variables found their way into the final model; the great number of candidate predictor variables affects de number of noise variables in a model (Derksen and Keselman, 1992).

In the following modelling stage we applied several tests to residuals such as autocorrelation and partial autocorrelation, normal distribution, serial correlation LM test and White heteroscedasticity test, as well as stability tests for the model, CUSUM and CUSUM-square, including tests for testing breaking point test (Chow test).

Our empirical analysis also includes a VAR model with Impulse-Response analysis and Variance Decomposition, Johansen cointegration tests to find out if the variables selected are cointegrated. If a cointegration existed then we estimated a Vector Error Correction model for the cointegrated variables. Vector autoregression model (VAR) is a multivariate autoregressive model in which all variables are endogenous while allowing the value of variables to depend on more than its own lags being thus able to capture more features of the data, especially the interdependencies between multiple time series.

For a set of \( n \) time series variables \( y_t = (y_{t1}, y_{t2}, \ldots, y_{tn})' \), a VAR model of order \( p \) (VAR(p)) can be written as:

\[ y_t = A_1 y_{t-1} + A_2 y_{t-2} + \ldots + A_p y_{t-p} + u_t \]

where the \( A_i \)'s are \((nxn)\) coefficient matrices and \( u_t = (u_{t1}, u_{t2}, \ldots, u_{tn})' \) is an unobservable i.i.d. zero mean error term.

The lag length specification \( p \) can be determined by cross-equation restrictions using a LR test and information criteria (Akaike Information Criterion - AIC or the Schwarz Information Criterion - SC). A disadvantage of the LR test is that it is valid under the assumption that the errors are normally distributed and since the normality assumption is too restrictive and unrealistic, we will use information tests that require no such
assumption. The estimated VAR model is usually tested with the following set of statistics: block significance tests, Impulse Responses tests and Variance Decomposition.

The Impulse–Response analysis is used to see how the variables will respond if a unit shock is applied to the error of each variable. Variance decomposition gives the percentage of the variance in the dependent variable that is due to its own shock opposed to shocks to the other variables, because a shock in a variable will affect not only itself but also other variables due to the simultaneous equations setting of VAR. If all linear combinations of the series would be nonstationary, meaning that they would not have a constant mean to return to, then there is no long-run relationship between them. Also if there is a long-run relationship between them, using first differenced data will lose the information from the data.

Applying the Johansen cointegration allows us to test if the data are cointegrated and if so then a vector error correction model (VECM) can be estimated. Cointegration shows up in times series because they share common stochastic trends that are eliminated by cointegrating linear combinations; the linear combination is referred to as long-run equilibrium. Since our intuition is that the selected series respond to shocks altogether, we will test them for cointegration. Since the Engle-Granger method of testing for cointegration cannot account for cases in which the causality between y and x runs both ways, we will use the Johansen cointegration method. Johansen cointegration test will report two statistics, the Trace statistic for determining the cointegration rank and the Maximum Eigenvalue statistic (Juselius, 2006).

We have constructed two groups of variables, one for BET returns and another for BET-FI returns with the following data: industrial production index (IPI), the wholesale price index (WPI), the consumer price index (CPI), the nominal Romanian leu – euro exchange rate (EXRR), foreign exchange reserve of the Romanian Central Bank (EXR), interbank interest rate (IR), official interest rate (RD), M2, the oil price (West Texas Intermediate), gold price (GOLD), short term 3-Month Treasury bill’s rate (TB3M) and 10-year yield of T-bond (DGS10Y). We tested for multicollinearity in both groups, taking a 0.94 significance level, and we concluded that there is multicollinearity between the following variables: M2, EXR and WPI, RD and IR, DGS10Y and TB3M. As a result in the estimated models there will be used only one variable from the groups where multicollinearity was detected.

We have constructed stationarized time series taking the first difference in logarithms and we tested the constructed series using ADF and PP tests. All series passed the tests with the exception of M2 which due to the fact that it was stationarized at I(2) was excluded from the model. Two APT models were estimated using the stepwise procedure and the results are presented below.

Therefore the APT model for BET returns will be:

\[ DL_{BET} = -1.917*DL_{EXRR} - 0.848*DL_{IR} +0.741*DL_{MSCI} + 0.341*DL_{WTI} - 0.444*DL_{GOLD} - 0.068*DL_{TB3M} \]

while the model for BET-FI returns is:

\[ DL_{BETFI} = -2.043*DL_{EXRR} - 1.405*DL_{IR} + 0.918*DL_{MSCI} + 0.284*DL_{WTI} - 0.905*DL_{GOLD} \]

The results obtained with the stepwise procedure indicate that BET’s returns are positively correlated with MSCI and oil returns and negatively with exchange rate, Romanian interest rate, short term T-bill and gold.

In the case of BET-FI returns it may be noticed that they are also positively correlated with MSCI, oil returns and negatively correlated with exchange rate, gold and Romanian interest rate and the short-term T-bill is no more selected in the regression.
For both models the Serial Correlation LM Test accept the null hypothesis of no serial correlation of residuals, and also the Heteroskedasticity Test shows no evidence of autoregressive conditional heteroskedasticity (ARCH) in residuals.

The distribution of BET’s residuals is platykurtic with the rejection of null that it follows a normal distribution while the distribution of BET-FI returns is leptokurtotic. We have applied a Chow Breakpoint Test for detecting possible breaking points in the time series and we have found a breaking point for both models for December 2008. Therefore we have re-estimated the model for BET over the period 2002/06-2008/11 while maintaining the previous regressors and by the stepwise procedure there were selected only the EXRR, IR, MSCI and WTI variables and for the subperiod 2008/12-2011/05 EXRR, MSCI, WTI, Gold and TB3M were selected. The re-estimated model for BET-FI retained for the first subperiod the same variable as in the case of BET, that is EXRR, GOLD and MSCI less oil returns, while for the second subperiod EXRR, MSCI and GOLD. Since the number of observations for the second subperiod is of 30 observations, this may impact upon the significance of regression.

Therefore the estimated APT over the 2002/06-2008/11 subperiod will be:

\[
\begin{align*}
DL_{\text{BET}} &= -1.866*DL_{\text{EXRR}} - 0.752*DL_{\text{IR}} + 0.680*DL_{\text{MSCI}} + 0.290*DL_{\text{WTI}} \\
DL_{\text{BETFI}} &= -1.991*DL_{\text{EXRR}} - 1.527*DL_{\text{IR}} + 0.940*DL_{\text{MSCI}}
\end{align*}
\]

while for 2008/12-2011/05 subperiod:

\[
\begin{align*}
DL_{\text{BET}} &= -2.011*DL_{\text{EXRR}} + 1.070*DL_{\text{MSCI}} - 0.074*DL_{\text{TB3M}} - 0.619*DL_{\text{GOLD}} + 0.283*DL_{\text{WTI}} \\
DL_{\text{BETFI}} &= -3.432*DL_{\text{EXRR}} + 1.642*DL_{\text{MSCI}} - 1.185*DL_{\text{GOLD}}
\end{align*}
\]

BET is positively correlated for the first subperiod with MSCI and oil returns and negatively correlated with exchange rate and interest rate. It is interesting to note that following the onset of financial crisis, GOLD shows up included in the regressors group indicating a switching in the dynamics of investors who sought safer investment as gold. It is also interesting to note that the interest rate from the first subperiod is replaced by short-term T-bill yield in the second subperiod, a possible explanation may be that since the access to domestic financing markets dried up, the funds were largely impacted by the international capital markets. For the second subperiod BET-FI returns are influenced by the same factors as BET with the difference that the variation of gold returns are more important than in the case of BET, a possible explanation lies within the construction of indices, since BET-FI includes only the financial institutions, while BET includes companies from several sectors.

Stability tests CUSUM and CUSUM of squares indicate that the APT models, estimated over the 2002-2011 period, are stable. BET-FI model slightly exceeds the significance level in the period 2007/08-2008/09 previous to the financial crisis.

![Figure 1. Stability tests for the APT models over the 2002/06-2011/05](image)
For understanding the interdependence between the dynamics of Romanian stock exchange indices and macroeconomic factors, we have estimated two VAR models for both BET and BET-FI indices using stationarized series at the first differences I(1) by testing lag length with Lag Exclusion Test and Lag Length Criteria. For both models AIC and LR test suggested models with two lags. The estimated model for BET is presented below.

\[ DL_{BET} = 0.166*DL_{BET}(-1) + 0.109*DL_{BET}(-2) + 0.149*DL_{IR}(-1) + 0.010*DL_{IR}(-2) - 0.264*DL_{EXRR}(-1) + 1.164*DL_{EXRR}(-2) - 0.252*DL_{GOLD}(-1) + 0.521*DL_{GOLD}(-2) + 0.028*DL_{TB3M}(-1) + 0.097*DL_{TB3M}(-2) + 0.090*DL_{WTI}(-1) - 0.086*DL_{WTI}(-2) + 0.152*DL_{MSCI}(-1) + 0.215*DL_{MSCI}(-2) \]

Studying the shocks between the endogenous variable of VAR for BET by Impulse Response and Variance Decomposition it was suggested that BET’s returns are largely affected by short-term T-bill rate, exchange rate and to a lesser degree by oil, MSCI and gold returns. In the light of the previous results achieved by the APT models for the subperiods indicated by Chow tests, it may be interesting to investigate in a following paper the influence of gold and exchange rate on BET and BET-FI.

In the case of the estimated VAR with two lags for BET-FI index we found evidence that indicate a greater influence of the exchange rate and gold over the returns of BET-FI, and a lower influence of MSCI, oil and interest rate.

We have estimated another two VAR as indicated by the Chow tests for the subperiods. The results indicated that in the period previous to the crisis both BET and BET-FI were affected in a lesser degree by the external shocks, being mostly affected by exchange rate and domestic interest rate and partially by MSCI and oil price. After the breaking point, not only the structure of the macroeconomic variable was changed, but also the intensity with which they affected the volatility of Romanian indices. The gold price and short-term T-bill were included in both models and they had a high influence over them.

Figure 2. Impulse Response for BET’s returns
After checking that all variables are non-stationary in their levels form, we tested the variables BET, EXRR, GOLD, MSCI, IR, WTI and TB3M for cointegration using Johansen Cointegration test up to lag length 8. Running the cointegration test, AIC indicated a cointegration relationship at lag 4 for intercept and trend in CE (linear trend in VAR). We estimated the VEC, as suggested by AIC test at lag 4, the null of no cointegrating vectors is rejected by the trace statistics, therefore there exists at least one cointegrating vector among variables. The trace statistics test was confirmed by Maximum Eigenvalue test.

The same procedure was applied to BET-FI and AIC selected lag length 4 for intercept and trend in CE. The trace statistics indicated 2 cointegrated vectors while the Maximum Eigenvalue test suggested only one. Therefore we estimated a VEC (1 4) for BET-FI. In figure 3 we plotted the cointegrating vectors for both BET and BET-FI as resulted from the estimated VEC models.

We set out to discover whether meaningful relationships can be established between Romanian stock exchanges and macroeconomic variables. The results indicated that domestic variables such as official interest rate and interbank rate and foreign variables as MSCI, gold, oil and short-term 3-month T-Bill’s yield affect the evolution of Romanian stock exchange indices.

The results obtained with the stepwise procedure indicate that BET’s returns are positively correlated with MSCI and oil returns and negatively with exchange rate, Romanian interest rate, short term T-bill and gold.

By applying a Chow Breakpoint Test we have found a breaking point for both models for December 2008. The evidence shows that in the period previous to the crisis both BET and BET-FI were less influenced by the external shocks, being mainly affected by exchange rate and domestic interest rate and partially by MSCI and oil price. After the breaking point, gold price and short-term T-bill were included in both models and the Impulse Response tests pointed out the intensity with which they affected the volatility of Romanian indices. The results for the second subperiod may be affected by a small sample bias due to the number of observations (30).

The results of the model VEC (1 4) estimated over the 2002-2011 period suggested the existence of a long-term equilibrium relationship between BET, BET-FI and the macroeconomic factors taken into consideration.

As future work in the field, we could further explore the complex interdependence between the endogenous variables from the VAR and VEC models in a VARMAX setting.
Another direction could be given by the re-testing of the models employing longer time series after the breakpoint as well as using an SVAR model for testing and forecasting.

References