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Estimating temporary and permanent stock price innovations on Croatian capital market

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Abstract. This paper evaluates the size and duration of temporary and permanent stock price innovations on Croatian capital market in the structural VAR (vector autoregression) framework with Blanchard and Quah (1989) decomposition. The purpose is to identify the effects of temporary price innovations in order to determine to which extent future stock prices can be predicted. Temporary components present in stock prices are explained throughout the mean-reversion hypothesis. This means that stock prices deviate from the fundamental values, but they will revert to their mean. In that way, to some extent, it is possible to predict future price movements. The results show that for the observed period from January 2000 to September 2013, temporary innovations account for only 2.62% of price variability over a two-year horizon. This means that forecasting the future movements of stock prices on Zagreb Stock Exchange is a difficult task.

Key words: temporary and permanent stock innovations, stock market, structural VAR, random walk hypothesis

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1. Introduction

Standard present value models of stock evaluation assume that investors buy stocks in order to hold them for a certain amount of time. In the holding period the investor realizes dividends, thus the stock price itself is a present value of future cash flows. This relationship describes the fundamental factors behind stock price movements and it is related to the Efficient Market Hypothesis (EMH). If all of the information about the future is already incorporated in stock prices, we cannot predict what will happen with the prices in the future. The random walk theory compliments the EMH and suggests that the random walk of price movements generates permanent innovations in stock price movements, while temporary innovations are a result of a stationary component of prices. Nevertheless, there has been a debate on the legitimacy of the EMH and the random walk theory. Authors have

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started to recognize temporary and permanent stock price innovations and question them for the last thirty years, both in academic and investors' circles. Questions emerged whether only fundamental factors affect stock price movements. The first papers to appear were Shiller [16], Fama [7] and Summers [19]. Shiller [16] criticized the EMH, by concluding that movements in stock prices are somewhat caused by changes in expected real interest rates. Fama [7] argued that stock returns should be negatively correlated with expected inflation, which is approximated by a short-term interest rate. Summers [19] introduced temporary stock price innovations in order to explain deviations between the variance of stock prices and the variance of dividend streams. He concluded that stock prices take temporary swings from fundamental values. Temporary components present in stock prices are explained throughout the mean-reversion hypothesis. This means that stock prices deviate from the fundamental values, but they will revert to their mean. In that way, to some extant, it is possible to predict future price movements. Some explanations about this phenomenon are given in Shiller [17], Blanchard and Watson [5], etc. If the evidence exists that temporary innovations (the mean-reverting component) make a large part of price movements, stock returns are predictable and thus the Efficient Market Hypothesis does not hold. Fama and French [8] explain that temporary shocks uncorrelated with shocks to rational forecasts of dividends have no effect on expected dividends and no long-term effects on expected stock prices. They suggested taking caution in treating stock prices or stock returns as rational reflections of fundamental values, especially when implementing macroeconomic theories such as the q investment theory (which assumes that asset prices reflect the present value of future asset rents). Those first findings were followed by studies of Lo and MacKinlay [13], Kim et. al. [12], Gallagher and Taylor [9], Hess and Lee [10], etc. The mentioned authors found that temporary stock price innovations exist and affect stock price movements. The question remains how big the size and the dynamics of these effects are, which gives us answers to which extent it is possible to predict future movements of stock prices or returns. A lot of studies examining the Croatian stock market have emerged in the last couple of years (Vizek and Dadić [20], Barbić and Čondić-Jurkić [2], Benazić [3], Hsing [11], Barbić [1], Dadić [6], etc.). None of them have analyzed and separated stock innovations into temporary and permanent factors. The purpose of this paper is to analyze co-movements between stock market returns and interest rates on the Croatian stock market in order to identify whether temporary stock price innovations exist and in which way they affect stock prices by the following explanations given in Shively [18:499]: "real interest rates are intrinsically related to real stock prices through standard present-value models and they should be highly informative to identifying the existence, size and dynamic effect of independent temporary and permanent stock price innovations". In that way we hope to contribute to the existing literature by examining the size and duration of temporary stock price innovations. Since the theory suggests that the mentioned innovations are temporary swings from the fundamental values, which have no effect on stock prices in the long run, a structural VAR (vector autoregression) model with defined long-run zero restriction in order to identify two structural shocks (temporary and permanent) is applied. This is called the Blanchard and Quah [5] VAR framework. Finally, Martínez-Moya et al. [14] explain why interest rate fluctuations have a significant influence on stock price fluctuations: an increase in interest rates leads to an increase in interest expense of firms, which reduces cash flows from future dividends, thus negatively impacting stock prices. Furthermore, fluctuations in interest rates affect the opportunity cost of assets, and they are also linked to real activity in the economy, which affects the expectations of future cash flows. In that way, this paper estimates the size and duration of two structural shocks (temporary and permanent) in Croatian stock movements, by examining the relationship between real stock returns and real interest rates. The structure of the paper is as follows. The second section describes the methodology applied in this study, while the third section deals with data description and results of the empirical analysis. The final, fourth section concludes the paper.

2. Blanchard and Quah (1989) framework

Blanchard and Quah's [4] approach to modeling structural VARs is as follows. A structural moving average model of variables of interest is written as:

$$\boldsymbol{x}_t = \boldsymbol{A}(\boldsymbol{L})\boldsymbol{\epsilon}_t, \tag{1}$$

i.e.

$$\begin{bmatrix} sr_t \\ \Delta ir_t \end{bmatrix} = \begin{bmatrix} A_{11}(L) & A_{12}(L) \\ A_{21}(L) & A_{22}(L) \end{bmatrix} \begin{bmatrix} \epsilon_t^T \\ \epsilon_t^P \end{bmatrix}, \tag{2}$$

where $\boldsymbol{x}_t = \begin{bmatrix} sr_t \ \Delta ir_t \end{bmatrix}'$ is the vector of stationary endogenous variables, sr_t is real stock return and Δir_t is the differenced real interest rate. $\boldsymbol{\epsilon}_t = \begin{bmatrix} \epsilon_t^T \ \epsilon_t^P \end{bmatrix}'$ is a vector of structural disturbances, ϵ_t^T and ϵ_t^P are temporary and permanent stock price innovation, respectively. $\boldsymbol{A}(\boldsymbol{L}) = \boldsymbol{A}_0 + \boldsymbol{A}_1 L + \boldsymbol{A}_2 L^2 + \ldots$ is a matrix polynomial of the lag operator L. $A_{ij}(L), i, j \in \{1, 2\}$ is a polynomial in the lag operator L. Moreover, structural disturbances have the following properties:

$$E(\boldsymbol{\epsilon}_t) = \boldsymbol{0},\ E(\boldsymbol{\epsilon}_t \boldsymbol{\epsilon}_t') = \boldsymbol{I} \text{ and } E(\boldsymbol{\epsilon}_t \boldsymbol{\epsilon}_s') = \boldsymbol{0}\ \forall\ t \neq s, \tag{3}$$

i.e. structural disturbances are by definition serially uncorrelated and mutually orthogonal, with a normalized variance matrix.

The vector moving average representation of the VAR model is defined as:

$$\boldsymbol{x}_t = \Theta(\boldsymbol{L})\boldsymbol{e}_t, \tag{4}$$

where $\Theta(\boldsymbol{L}) = e_t + \Theta_1 e_{t-1} + \Theta_2 e_{t-2} + \ldots$ and $\boldsymbol{e}_t = \begin{bmatrix} \boldsymbol{e}_t^T \ \boldsymbol{e}^P \end{bmatrix}'$ is a vector of reduced form disturbances. Properties of reduced form disturbances are:

$$E(\boldsymbol{e}_t) = \boldsymbol{0},\ E(\boldsymbol{e}_t \boldsymbol{e}_t') = \Omega \text{ and } E(\boldsymbol{e}_t \boldsymbol{e}_s') = \boldsymbol{0}\ \forall\ t \neq s. \tag{5}$$

By comparing equations (1) and (4) and taking into account matrix polynomials $\boldsymbol{A}(\boldsymbol{L})$ and $\Theta(\boldsymbol{L})$ it follows that

$$\boldsymbol{e}_t = \boldsymbol{A}_0 \boldsymbol{\epsilon}_t. \tag{6}$$

In order to calculate $\boldsymbol{A}(\boldsymbol{L})$, we need an estimate of $\boldsymbol{A}_0$, which can be obtained by taking the variance of each side of equation (6):

$$\Omega = \boldsymbol{A}_0 \boldsymbol{A}_0'. \tag{7}$$

Since the model given in (4) is under-identified, additional restrictions need to be made in order to obtain estimates of $\boldsymbol{A}_0$. $\boldsymbol{A}_0$ is a 2·2 matrix. Thus we need four parameters to recover structural disturbances. Three are given by estimating $\hat{\Omega}$. This means one additional restriction is needed to identify the system exactly. Here, it is assumed that, according to the mentioned literature, temporary stock price shocks do not influence stock returns in the long run. Formally, the restriction is given as

$$A_{11}(L) = \sum_{i=1}^{\infty} a_{ii}(i) = 0 \text{ in } (2).$$

3. Data and empirical analysis

This section deals with estimation of a two-variable VAR model, with a vector of endogenous variables $\boldsymbol{x}_t = \left[sr_t \ \Delta ir_t\right]'$, where Δ denotes the difference operator. Data on the Croatian stock market index, CROBEX, and 91 day Treasury bill interest rates were gathered from Zagreb Stock Exchange [21] and from the Ministry of Finance [15]. It refers to monthly data from January 2000 to September 2013[‡]. In order to apply the Blanchard and Quah technique, at least one of the variables must be non-stationary since stationary variables do not have a permanent component. In order to use the method, all of the variables must be stationary in the VAR model. The CROBEX variable is in natural logarithm, while the interest rates were adjusted by a consumer price index in order to reflect real interest rates. Figure 1 represents movements of the two variables.

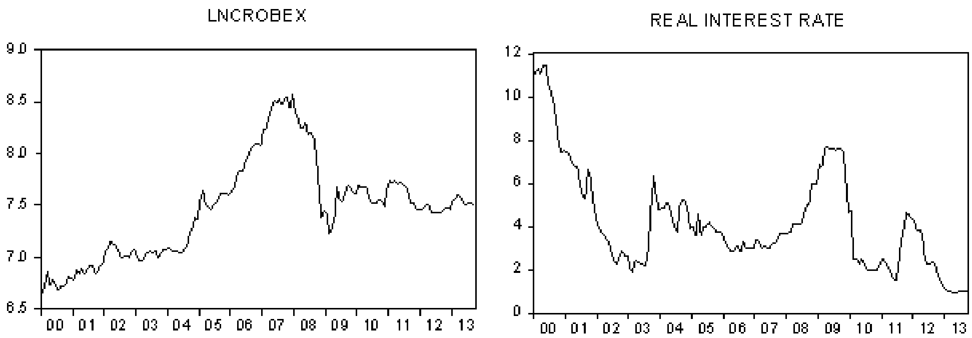

Figure 1: *CROBEX and real interest rates in the period from January 2000 to September 2013*

Source: Authors.

To determine the order of integration, an Augmented Dickey-Fuller (ADF) test was performed on the variables in levels and differences. The lag length was chosen based on the Schwartz Information Criterion. Two versions of the ADF test were performed on the variables in levels: one including both a constant and a trend as deterministic components, and one only with the constant included. Two versions

[‡]This was the longest time span available.

of the test were performed on the differenced variables as well: one including the constant in the ADF equation, and the other with none of the deterministic components. Table 1 shows the result test values on the 5% level of statistical significance, values in round brackets give information about the chosen lag length and values in square brackets give information about the p-value of each test value. Critical values are used as referred to in MacKinnon (1996).

Variable	**Deterministic components**	
	Constant, trend	**Constant**
Ln(crobex)	-3.4373 (1) [0.9116]	-2.8789 (1) [0.3386]
Real interest rate	-3.4376 (1) [0.1401]	-2.8792 (1) [0.0361]
	Constant	**None**
Δ Ln(crobex)	-2.8789 (0) [0.0000]	-1.9428 (0) [0.0000]
Δ Real interest rate	-2.8792 (0) [0.0000]	-1.9434 (0) [0.0000]

Table 1: *ADF Unit root tests results*

Source: Authors' calculation.

As can be seen, all of the variables are $I(1)$, i.e. integrated of order one, because they have unit root in levels and are stationary in the first differences. Since the variables are $I(1)$, there exists a possibility of cointegration between them. If they are cointegrated, a structural VECM (vector error correction model) has to be applied instead of a structural VAR. In order to check for a possible cointegration, a Johansen Cointegration test was applied over variables in levels. Table 2 reports the results of the analysis. Trace and Maximum Eigenvalue tests suggest that there is no cointegration among variables. This means that it is appropriate to use the first differences of the variables in the SVAR model.

Test	**H_0**	**Eigenvalue**	**Test Statistic**	**5% Critical Value**	**p-value**
Trace	$r = 0*$	0.0616	13.3936	15.4947	0.1011
	$r \leq 1$	0.0189	3.0875	3.8415	0.0789
Maximum Eigenvalue	$r = 0*$	0.0616	10.3061	14.2645	0.1926
	$r \leq 1$	0.0189	3.0875	3.8415	0.0789

Note: * denotes rejection of the null hypothesis at the 0.05 level.

Table 2: *Results of Johansen Cointegration test for a number of cointegration vectors*

Source: Authors' calculation.

In order to estimate a VAR model, a lag length needs to be determined. Several criteria have been used: Final prediction error (FPE), Hannan-Quinn (HQ) and Akaike (AIC) information criteria have pointed out that a lag length of $k = 1$ is appropriate. Thus, a VAR(1) model was estimated with intercept included. Another model was estimated with a dummy variable included accounting for the crisis period, but the results were almost identical to the results of the initial model. Henceforth, the given results in the rest of this paper refer to the initial model. The final formal requirement for the use of the Blanchard and Quah framework is that the estimated VAR model is stable. All of the roots of the model lie within the unit circle, thus the stability of the model is fulfilled. Now, a structural VAR model can be estimated by setting the long term influence of temporary stock price innovations to zero.

Since we are interested in the effects of temporary and permanent innovations on stock returns, an impulse response function was constructed based on the estimated model. Figure 2 shows an impulse response function for stock returns. As can be seen, temporary stock innovations have a positive effect in the first month, followed by a smaller negative response in the second, which almost vanishes in the third month. From the fourth month, stock returns return to their average value. Permanent innovations, on the other hand, have negative effects on stock market returns and their effects vanish after the third month. Thus, it can be concluded that temporary shocks have little and short-life effects on stock return movements. In that way, it is very difficult to predict future movements of return.

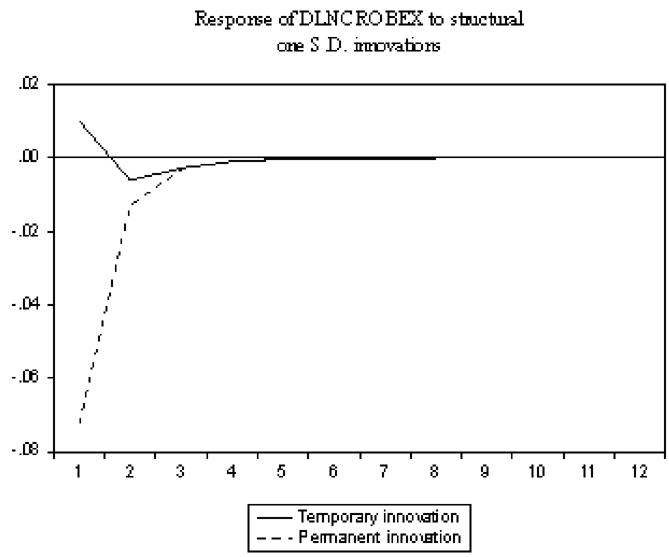

Figure 2: *Impulse response function of stock returns to temporary and permanent shocks*

Source: Authors.

Furthermore, a variance decomposition of stock returns has been made in order to measure the importance of temporary innovations in stock price fluctuations. Table 3 shows the results of the analysis. Temporary price innovations have a marginal impact on stock price movements. In the first month they account for 1.89% of price volatility, in the second 2.49% and up to 2.62% in other horizons. Therefore, the size of the mean-reverting component is very small, which means it is difficult to forecast future price movements on the Croatian capital market. On the other hand, fundamental innovations account for over 97% of stock price movements.

The results are not very surprising. If we examine the autocorrelation and partial

Month	Type of innovation	
	Temporary	Permanent
1	1.888664	98.11134
2	2.487404	97.51260
3	2.608685	97.39131
4	2.622117	97.37788
5	2.623420	97.37658
6	2.623542	97.37646
12	2.623555	97.37645
18	2.623555	97.37645
24	2.623555	97.37645

Table 3: *Variance decomposition of DLNCROBEX*

Source: Authors' calculation.

autocorrelation function of returns of CROBEX given in Figure 3, the correlograms suggest that the returns are a white noise process. All of the estimated coefficients of autocorrelation and partial autocorrelation[§] lie within the interval of ± 2 S.E., i. e. they are not statistically significant.

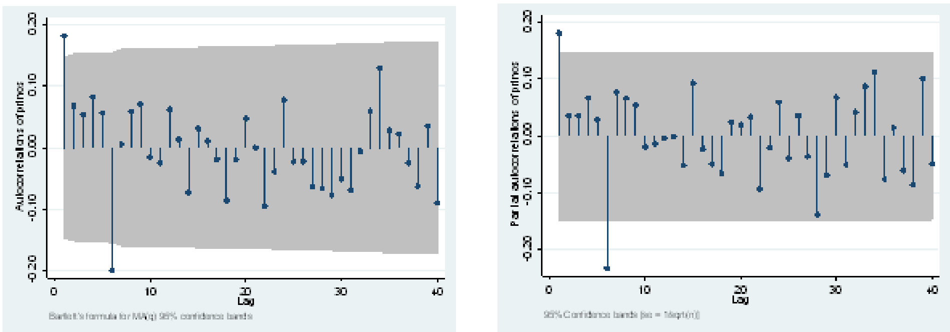

Figure 3: Autocorrelation and partial autocorrelation function of stock returns

Note: The gray area on the correlogram refers to the 95% confidence bands of ±2 S.E.
Source: Authors.

4. Discussion and conclusion

Random walks, Efficient Market Hypothesis and stock price predictability have been ongoing issues in academic and investors' circles for decades. Studies which distinguish temporary and permanent innovations in stock price index movements in the 1980s started to appear. Authors started to question the randomness of price move-

[§]Except for the coefficients on the sixth lag.

ments. Some evidence started to appear that stock prices or returns can be predicted, at least to some extent.

Temporary components present in stock prices are explained throughout the mean-reversion hypothesis. This means that stock prices deviate from the fundamental values, but they will revert to their mean. The bigger the impact of temporary components on stock price index movements, the bigger the probability to accurately predict future price/return movements. The theory suggests that temporary innovations have effects on stock prices in the short run, but in the long run these effects vanish, and permanent innovations have effects which are present both in the short and long run. Therefore, this paper employs a structural VAR model with Blanchard and Quah [4] decomposition. This framework estimates structural innovations by forcing a long run restriction on effects of temporary innovations.

The results of the analysis suggest that for the examined period from January 2000 to September 2013 temporary innovations have positive but small effects on stock price index movements. They account for only 2.62% of price variability over a two year horizon. In that way, it is not an easy task to predict future price movements on the Croatian stock market. This paper is a first attempt in Croatia to decompose stock price index movements to temporary and permanent innovations. Thus, more work needs to be done. Other theories on stock price movements and their components exist, which might describe the movements on the Croatian capital market more accurately. Future work includes decomposition stock price movements by using other relevant theories of stock evaluation and comparison of the results with previous findings in the literature.

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