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HOW THE CONTAGION IS TRANSMITTED TO THE MACEDONIAN STOCK MARKET? AN ANALYSIS OF CO-EXCEEDANCES

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Abstract

The aim of the paper is to analyze the transmission of shocks from selected developed and Southeastern European stock markets to the stock market of North Macedonia. Using the Bae, Karolyi, and Stulz (2003) co-exceedance methodology, we find that the probability of contagion from the stock markets of United States, Serbia and Bosnia and Herzegovina to the Macedonian stock market increased during the Global Financial Crisis. Regarding the asset classes, we show that contagion is positively associated with the volatility of Eurostoxx50 index, while negatively with the return of the euro dollar exchange rate and the yield of the 10-year US Treasury Note. The results have important implications for portfolio diversification and the asset allocation decisions of investors.

Keywords: *Stock market, co-exceedance, multinomial logit regression, transmission, contagion*

JEL classification: *C02, C11, C45, C46, C63*

1. Introduction

The focus on how shocks that arise from financial crisis are transmitted across stock markets is a relatively new phenomenon, having entered the finance literature after the seminal paper of King and Wadhwani (1990). Nevertheless, the empirical literature that investigates it is already vast and extensive (e.g., Engle, Ito, and Lin 1990; Masulis, Hamao, and Ng 1990; Forbes and Rigobon 2002; Bae, Karolyi, and Stulz 2003; Baur and Schulze 2005; Baur and Lucey 2009; Dajcman 2013; Bekaert et al. 2014; Horváth, Lyócsa, and Baumöhl 2018). Its development was also a natural process, emerging as a result of the numerous financial shocks experienced in the last three decades. Consequently, numerous papers have examined the transmission of shocks during different financial crisis, such as: the global October 1987 stock market crash, the Black Wednesday of 1992, the collapse of the

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Mexican pesos in 1994, the eastern Asian crisis of 1997 (Asian flu), the Rubble crisis of 1998 (the Russian flu), the downfall of Long-Term Capital Management in 1998, the devaluation of the Real in 1999, the dot-com bubble in 2000 and the more recent Global Financial Crisis of 2007-2008.

Two words with rather negative connotation such as "volatility spillovers" and "contagion" emerged to indicate shock transmission that cannot be explained by fundamentals. The term "contagion" is adopted from the biological terminology: "a virus-which can be transmitted quickly through direct or indirect contact". Although the biological term is rather straightforward, in the finance literature the definition has shifted both among authors and across time and has been sometimes mixed with interdependence (see Forbes and Rigobon 2001; Pericoli and Sbracia 2003; Baur and Lucey 2009). Forbes and Rigobon (2003) make a distinction between interdependence and contagion, arguing that interdependence is the mutual connection which exists among stock markets during crisis and non-crisis periods, while contagion is the transmission of shocks only during crisis (turbulent) periods. Moreover, many authors have been proposing quantitative measures of contagion in order to investigate and explain it. The review of the methodologies can be found in Karolyi (2003) and Dungey et al. (2005).

In the present paper, we employ the methodology of Bae, Karolyi, and Stulz (2003) to investigate the transmission of shocks from four leading developed markets (US, Germany, France and the UK) and the seven Southeastern European (SEE) markets on the Macedonian stock market. The selection of the US, German, French and UK stock markets is based on the contagion literature (for example, Christiansen and Ranaldo 2009; Horváth, Lyócsa, and Baumöhl 2018), while we include all SEE markets where data are available. Similar selection of the stock markets can be found in Dajcman (2014), where contagion on the Croatian stock market is examined.

The literature tackling negative shock transmission in the Southeastern Europe (SEE) region, where North Macedonia belongs, has been scarce. The only studies are the ones of: Dajcman (2014), Tevdovski (2014), Angelovska (2017), Baranova (2018) and Tevdovski and Stojkoski (2021). In this paper, we build upon this literature and contribute in two ways. First, this is the first paper that investigates the potential contagious relationship from different stock markets to the Macedonian stock market. Second, we document contagion effects during a large distress episode - the Global Financial Crisis (GFC), when the Macedonian stock market experienced much stronger fall in comparison with leading European markets. In the period from April 2007 to April 2009, the fall of the Macedonian stock market index was 74%, while in same period the decrease of the UK and the German stock markets was 35% and 41%, respectively. Consequently, the overall findings of this paper might help both policy makers and investment managers in the international portfolio diversifications.

The rest of the paper is organized as follows. The second section presents the literature review, which is systematized based on the financial contagion methodological approach. The third section presents the applied methodology, while data and empirical results are provided in the fourth section. The last section concludes.

2. Literature review

The empirical literature of financial contagion employs different methods. One of the earlier methodologies is the method based on correlation coefficients. The methodology emerged from the paper of King and Wadhwani (1990), who defined contagion as a statistically significant growth of the correlation coefficients during turmoil period. However, a constraint of this methodology is that the correlation coefficients may be biased, because of the characteristics of the financial time series which feature heteroscedasticity. This problem was discussed by Forbes and Rigobon (2002), among others. The proposed solution was to examine contagion of capital markets based on the correlation coefficients using a multivariate method, thus defining it as a test of determining the change in the covariance matrix (DCC) (see Rigobon 2003). Basically, the DCC matrix test compares the covariance matrix of two subgroups of capital markets returns, one for the return during a stable period (low volatility), and the other during a crisis period (high volatility). However, a weakness of this approach is the ad hoc process of defining the crisis and stable periods (Pontines 2009).

Another method that has been widely used in examining the effect of contagion is the different varieties of the GARCH methodology, especially the DCC-GARCH model which tackles the problem of the heteroscedasticity of financial time series. Engle (2002) stressed that this model has the flexibility of the univariate GARCH model, but not the complexity of the conventional multivariate GARCH models. The approach has three advantages: (i) the calculation of the correlation coefficient of the standardized residuals is done directly, consequently directly incorporating in the calculation the aspect of heteroscedasticity; (ii) the model allows additional explanatory variables to be incorporated in the average equation for the calculation of the common factors; and (iii) the model enables us to have more markets in the calculation without adding too many parameters in the calculation. The method was widely applied in assessing the spillover and financial contagion (see Chiang, Jeon, and Li 2007; Kenourgis and Padhi 2012; Rehman 2016; Min and Hwang 2012; Mollah, Zafirov, and Quoreshi 2014; Chitedi 2015). However, this method can lead to undervaluation of the intensity and duration of the periods of market stress (Cappiello, Engle, and Sheppard 2006). Moreover, according to Horváth, Lyócsa, and Baumöhl (2018) in DCC GARCH models the stock market co-movement shows persistence, which in highly correlated time series in regressions usually lead to large size distortions and results in miss-specified model (see also Granger, Hyung, and Jeon 2001; Su 2008). This issues are circumvented by the analysis of co-exceedances (Horváth, Lyócsa, and Baumöhl 2018).

The analysis of co-exceedances was initially proposed by Bae, Karolyi, and Stulz (2003), defining negative exceedance as a market return bellow certain threshold, while co-exceedance as simultaneous exceedances in multiple markets. They proposed modeling exceedances and co-exceedances using the multinomial logistic regression. Christiansen and Ranaldo (2009), Lucey and Sevic (2010), Thomadakis (2012), Dajcman (2013) and Horváth, Lyócsa, and Baumöhl (2018) applied this methodology on the stock markets from the European Union. Markwat, Kole, and Van Dijk (2009) made modification in the framework based on the ordered logit regressions in order to model the occurrence of local, regional and global crashes as function of their past occurrences and financial variables. They showed that contagion occurs as a domino effect, where confined local crashes evolve into more widespread crashes.

Looking from the regional perspective, Dajcman (2014), Tevdovski (2014), Baranova (2018) and Tevdovski and Stojkoski (2021) are the only studies that employ the co-exceedance methodology in the SEE stock markets. In this context, Dajcman (2014) analyzed extreme returns co-movement between the Croatian and 10 European stock markets during major financial market distress periods in the period from the end of 2003 until the start of 2012, arguing that there is no evidence of contagion in the Croatian stock market. Baranova (2018) examined the effect of exceedances in the German stock market on five countries which are actively seeking to become part of the EU – Montenegro, Serbia, Turkey, Bosnia and Herzegovina and North Macedonia. Tevdovski (2014) and Tevdovski and Stojkoski (2021) analyzed extreme negative returns co-movement in the group of ten Southeastern European (SEE) stock markets and find that EU member countries are more dependent from signals from major EU economies while the EU accession countries are mainly influenced by the signals from the region.

3. Methodology

We base the extreme return co-movement analysis on the Bae, Karolyi, and Stulz (2003) methodology. We define extreme negative returns as those which lie bellow the 5th percentile of the stock market returns marginal distribution. Then, we are focusing on the pairs of markets. We construct a co-exceedance variable that counts the number of extreme negative returns in a pair wise manner (two markets) on a given day. It can take three values: 0, 1 or 2. The value of 0 implies that on given day there is no extreme negative return in both markets (j=0). The value of 1 implies that on given day there is extreme negative return only in one observed market (j=1) i.e., there is exceedance. The value of 2 implies that there is a simultaneous extreme negative return in both observed markets (j=2) i.e., there is co-exceedance (contagion).

Afterward we use the multinominal logistic regression for estimating the probabilities associated with the events captured in the categorical variable. This method offers a more consistent and efficient way of measuring co-exceedances between stock markets, because its co-exceedance measure is not biased in periods of high volatility, it is not restricted to linear phenomena, and it is easy to compute across time and assets (see Baur and Schulze 2005; Dungey et al. 2005). Additionally, an advantage of using the multinomial logistic analysis is that we can condition on attributes and characteristics of the exceedance events using control variables (explanatory variables or covariates) that are measured using information available up to the previous day (Bae, Karolyi, and Stulz 2003). A possible weakness of this definition is the small sample size of extreme returns, and the possibility of global shocks causing extreme returns. The multinomial logit model assumes that the probability of observing category i (of the three possible categories) is given by Equation (1) (Greene 2003):

$$P_i^* = \frac{\exp(\beta_i' x^*)}{[1 + \sum_{j=1}^{m-1} \exp(\beta_j' x^*)]} \tag{1}$$

where x is a T x n matrix of covariates (with n being the number of different covariates) and β the vector of coefficients (including a constant) of a particular category associated with the covariates. In this paper we included the following covariates: the Eurozone money market interest rate daily change return (three-month EURIBOR); 10-year US Treasury note daily yield change; the conditional volatility of the average Eurozone stock market returns, proxy by the EUROSTOXX50 returns, modelled as EGARCH (1,1) and the return of the euro dollar exchange rate. Following the empirical literature (Dajcman 2013; Dajcman 2014), we include a dummy instrumental variable in order to estimate whether the Global Financial Crisis significantly influenced the probability of contagion in the stock markets. The dummy instrumental variable takes value 1 for the crisis period from September 16th, 2008 to September 22nd, 2010, and zero for the other days.

Even though the multinomial logit model is one of the most commonly used models in studying multiple unordered choices (Wulf 2015), the coefficients of the multinomial logit model are hard to interpret and there may be a risk of misinterpretation. Therefore, following Greene (2003) we additionally estimate the marginal change in probability for one-unit change of the independent covariates, in order to test whether this change is statistically different from zero. The marginal effect (*θ*), is estimated following the equation of Greene (2003):

$$\delta_j = \frac{\delta P_j}{\delta x} = P_j[\beta_j - \sum_{k=0}^{2} P_k \beta_k] \quad (2)$$

The marginal effects are not constant across the range of a specific predictor, consequently in discrete choice models with multiple choices the marginal effects can be positive for some values of the predictor and negative for the others (Greene 2003). Having this in mind we estimate the probabilities of each of the three categories, p_{ij} by evaluating the covariates at their unconditional values:

$$p_{ij} = P_r(y_i = j|x_i) = \frac{\exp(x_i'\beta_j)}{\sum_{j=0}^{2} \exp(x_i'\beta_j)} \quad (3)$$

The goodness-of-fit is measured using the pseudo-R2 of McFadden (1974) where both unrestricted (full model) likelihood, Lω, and restricted (constants only) likelihood, LΩ, functions are compared:

$$P_j = 1 - (\frac{L\omega}{L\Omega}) \quad (4)$$

We use Stata software for economic models' estimation.

4. Data and empirical results

We analyze the co-exceedance of the pair wise returns between the Macedonian stock market index and eleven selected stock markets for the period from 06.04.2006 to 28.12.2016. The selected markets are represented by their indexes: FTSE 100 (for UK), DAX (for Germany), CAC 40 (for France), DOW 30 (for USA[1]), BET (for Romania), SBITOP (for Slovenia), CROBEX (for Croatia), BELEX15 (for Serbia), SASX10 (for Bosnia and Hercegovina), MONEX (for Montenegro), SOFIX (for Bulgaria) and MBI10 (for Macedonia). The returns were calculated as the differences in the logarithms of the daily closing prices. Days with no trading in any of the observed markets were left out. The data source for stock indices is Yahoo Finance and the web pages of the stock exchanges.

Table 1 presents the main descriptive statistics of the stock markets returns in the observed period. The Jarque-Bera test rejects the hypothesis of normally distributed time series. We also performed unit root tests and proved that the return series cannot be characterized as unit root processes. The results are in accordance with the general characteristics of the financial time series, which are usually fat tailed and nonstationary series. The developing markets on average have a higher standard deviation, as well as kurtosis, indicating a higher variation in their returns as well as a higher probability of extreme returns during this period. In particular, the Romanian and Montenegrin stock markets have higher volatility, while the lowest is the much more liquid US stock market. Regarding kurtosis, all SEE stock markets, except the Bosnian, have higher kurtosis than the leading US market.

Table 1. Descriptive statistics of the stock market indices returns

Stock exchange/ index	Arithmetic mean, in %	Median	Maximum	Minimum	Standard deviation	Skewness	Kurtosis	Jarque-Bera statistics
Developed Stock Markets								
CAC 40	-0.003	0.044	10.590	-9.470	1.646	-0.163	8.452	2716.930***
DAX 30	0.029	0.109	10.800	-10.780	1.601	-0.285	9.583	3977.040***
DOW 30	0.026	0.078	10.510	-10.930	1.288	-0.433	14.776	12698.600***
FTSE 100	0.007	0.047	9.380	-9.260	1.382	-0.164	10.437	5048.050***
Developing stock markets								
BELEX 15	-0.021	-0.010	21.310	-12.590	1.572	0.768	30.291	68052.340***
BET	-0.002	0.037	10.490	-17.900	1.795	-1.226	16.705	17655.230***
CROBEX	-0.009	0.000	14.780	-15.130	1.423	-0.070	25.674	46829.340***
MBI	-0.008	-0.035	19.300	-10.280	1.499	1.366	28.708	60875.720***
MONEX	0.005	-0.003	15.840	-11.930	1.660	0.661	14.602	12418.830***
SASX	-0.040	-0.010	11.400	-11.460	1.463	0.062	13.339	9737.020***
SBITOP	-0.018	0.001	13.770	-12.240	1.337	-0.145	17.637	19521.350***
SOFIX	-0.018	0.034	12.770	-15.100	1.432	-0.618	19.666	25436.980***

Source: Calculation by the authors.

Table 2 presents the number (days) of negative exceedances and joint occurrences of negative extreme returns (co-exceedances) between the observed pair-wise markets, based on the 5th percentile of the marginal empirical distribution. In general, the Macedonian stock market has a higher number of co-exceedances with the regional markets in comparison with the developed stock markets. The most negative co-exceedances are observed with the Serbian market (Belex15 index), while the lowest number of co-exceedances with the German market (DAX index).

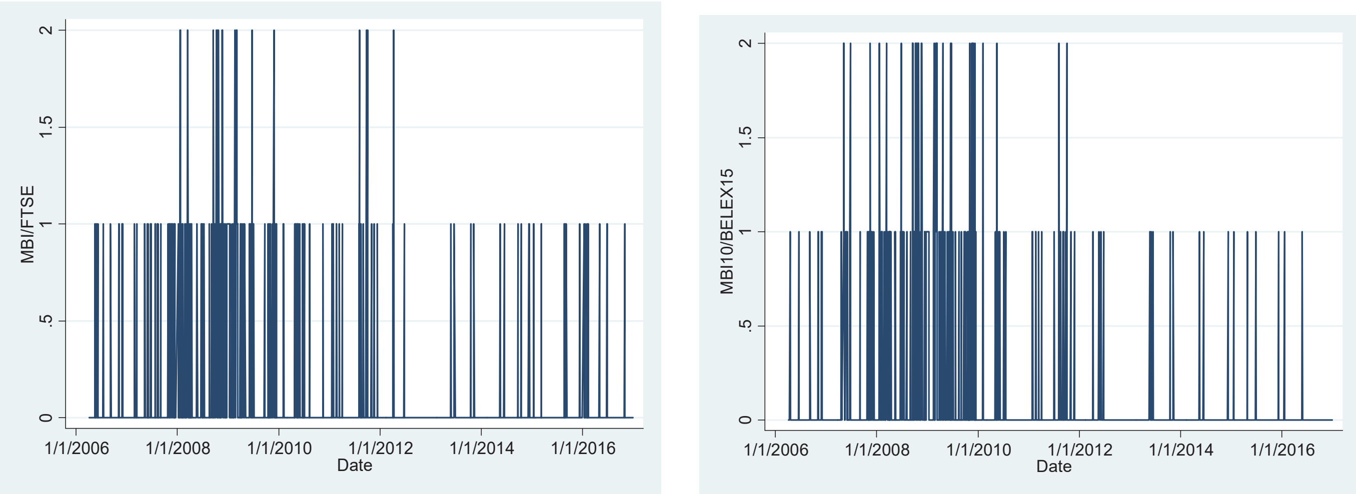
Table 2. Statistics of the counts of negative coexceedance of the daily stock index returns

Stock exchange/index	0	1	2
MBI10/Developed stock markets	Number of days (% of the whole sample of days)		
MBI10/CAC40	1989 (91.0%)	176 (8.1%)	21 (1.0%)
MBI10/DAX30	1987 (90.9%)	180 (8.2%)	19 (0.9%)
MBI10/DOW30	1990 (91.0%)	174 (8.0%)	22 (1.0%)
MBI10/FTSE100	1988 (90.9%)	178 (8.1%)	20 (0.9%)
MBI10/Developing stock markets			
MBI10/BELEX 15	2003 (91.6%)	148 (6.8%)	35 (1.6%)
MBI10/BET	1996 (91.3%)	162 (7.4%)	28 (1.3%)
MBI10/CROBEX	1998 (91.4%)	158 (7.2%)	30 (1.4%)
MBI10/MONEX	1994 (91.2%)	166 (7.6%)	26 (1.2%)
MBI10/SASX	1995 (91.3%)	164 (7.5%)	27 (1.2%)
MBI10/SBITOP	1994 (91.2%)	166 (7.6%)	26 (1.2%)
MBI10/SOFIX	1997 (91.4%)	160 (7.3%)	29 (1.3%)

Source: Calculation by the authors.

Figure 1. Time series of co-exceedance between the Macedonian stock exchange and selected developed and developing stock exchange markets

A) MBI10-BELEX15 **B) MBI10-FTSE100**



Source: Calculation by the authors.

Figure 1 shows the pairwise exceedances and co-exceedances between the Macedonian stock index and one regional index (Belex15) and between the Macedonian stock index and one developed stock market (FTSE100). The co-exceedances in the pairwise stock markets occurred mostly in the period of the Global Financial Crisis, while exceedances are present during the whole observed period. The same conclusion about the presence of the exceedances and co-exceedances between the Macedonian and other developing and developed stock markets could be made if they are plotted on the graphs.

We cannot directly interpret the increase of the number of co-exceedances in the pairwise stock markets as an indication of contagion. Dajcman (2014) argues that contagion must be separated from interdependence in the data, by controlling for the effect of covariates. In this way, the strength of contagion between the stock markets is measured as the fraction of co-exceedance that is not explained by the covariates included in the model (Bae, Karolyi, and Stulz 2003).

Tables 3a and 3b show the results of the multinomial logistic model for the pair-wise Macedonian and developing and developed stock markets. The time dummy variable of the Global Financial Crisis is statistically significant, for all the pair wise stock markets, except for the pair-wise co-movement of the Macedonian stock market with Montenegro (MONEX), France (CAC 40) and the German (DAX) stock market. The significant and positive dummy variable implies that the Global Financial Crisis increased the log odds of co-exceedance between the Macedonian stock market and the observed stock market. The conditional volatility of the Eurostoxx50 index is the only covariate that is statistically significant in all the pair wise stock markets. The euro dollar return is statistically significant for all the pair wise stock markets, except for the MBI10-SASX and MBI10-MONEX index. The yield of the 10-year US Treasury bond is statistically significant in explaining the log odds of co-exceedance between all the pairwise indexes except for the MBI-DOW, MBI-SBITOP and MBI-MONEX. On the other hand, the daily change of the three-month Euribor is statistically insignificant in explaining the log odds of co-exceedance between the Macedonian stock market and the developed and developing stock markets. The pseudo-R2 of the regressions is in the range between 0.055 and 0.107.

From the data in Table 3b, it follows that for example, in the pair MBI-DAX, a 1 unit (i.e., 1%) increase in the volatility is associated with a 0.641 increase in the relative log odds of outcome 1 (i.e., exceedance in one of the stock markets) versus outcome 0 (i.e., no co-exceedance in any of the two observed stock markets), and a relatively bigger increase of relative log odds (of 0.911) of outcome 2 (i.e., co-exceedance or contagion) versus the outcome 0.

Table 3a. Estimates of the multinominal logit regression model for the pairwise Macedonian and SEE stock markets

	MBI BELEX15	MBI CROBEX	MBI BET	MBI SASX	MBI SBITOP	MBI SOFIX	MBI MONEX
Intercept (1)	-3.315***	-3.805***	-3.478***	-3.467***	-3.134***	-3.239***	-3.382***
Crisis (1)	0.997***	1.301***	1.120***	0.918***	0.681***	1.296***	1.163***
Euribor3m (1)	0.029**	0.002	0.006	0.006	-0.002	-0.011	-0.001
Euro/dollar (1)	-28.282***	-25.012**	-51.901***	-23.745**	-15.533	-28.689***	-20.485**
10yUS (1)	-0.047	-0.064**	-0.084***	-0.030	-0.055**	-0.047	-0.063**
Eurostoxx50(1)	29.428**	55.146***	39.037***	44.993	30.726**	24.236*	36.770***
Intercept (2)	-6.347***	-6.404***	-6.004***	-6.151***	-6.773***	-6.564***	-5.984***
Crisis (2)	2.167***	1.163***	1.056**	1.255 ***	0.962*	1.185**	0.801
Euribor3m (2)	0.005	0.005	0.004	-0.033	-0.012	-0.028	0.004
Euro/dollar (2)	-27.743*	-52.289***	-67.766***	-23.795	-36.866**	-42.599**	-28.414
10yUS (2)	-0.156***	-0.099*	-0.186***	-0.110*	-0.057	-0.137**	-0.093
Eurostoxx50(2)	74.131***	98.987***	71.160***	80.974***	111.238***	98.092***	80.771***
Chi square	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Mc-Fadden	0.091	0.107	0.091	0.066	0.055	0.088	0.067

***, **, * Significance at the 1%, 5% and 10% levels, respectively

Source: Estimation by the authors

Table 3b. Estimates of the multinominal logit regression model for the pairwise Macedonian and the leading developed stock markets

	MBI DAX	MBI CAC	MBI FTSE	MBI DOW
Intercept (1)	-3.635***	-3.433***	-3.475***	-3.718***
Crisis (1)	0.663***	0.681***	0.715***	0.940***
Euribor3m (1)	-0.009	0.009	0.006	0.006
Euro/dollar (1)	-34.125***	-38.207***	-36.860***	-27.797***
10yUS (1)	-0.073**	-0.068**	-0.061**	-0.056*
Eurostoxx50(1)	64.127***	50.942***	53.436***	63.504***
Intercept (2)	-6.688***	-7.106***	-6.940***	-6.669***
Crisis (2)	0.769	0.954	1.418***	1.723***
Euribor3m (2)	-0.023	-0.017	-0.023	-0.007
Euro/dollar (2)	-59.032***	-60.940***	-47.748**	-49.975***
10yUS (2)	-0.176**	-0.200***	-0.210***	-0.035
Eurostoxx50(2)	91.114***	107.274***	91.007***	83.798***
Chi square	0.000	0.000	0.000	0.000
Mc-Fadden	0.077	0.078	0.079	0.090

***, **, * Significance at the 1%, 5% and 10% levels, respectively.

Source: Estimation by the authors.

In order to improve the interpretation of the multinomial logit model coefficients we follow Greene (2003) and calculate the marginal effects. The estimated marginal effects and probabilities of outcomes are reported in Tables 4a and 4b. The tables report: the probability of no exceedance (outcome 0), the probability of exceedance in only one stock market (outcome 1) and the probability of co-exceedance (outcome 2).

Table 4a. Marginal effects and probabilities of outcomes for the pairwise Macedonian and SEE stock markets

	MBI BELEX15	MBI CROBEX	MBI BET	MBI SASX	MBI SBITOP	MBI SOFIX	MBI MONEX
Crisis (1)	0.074***	0.106***	0.091***	0.073***	0.054***	0.115***	0.101***
Euribor3m (1)	0.002**	0.000	0.000	0.000	-0.000	-0.001	-0.000
Euro/dollar (1)	-1.610***	-1.338**	-2.950***	-1.433**	-1.003	-1.695***	-1.230**
10yUS (1)	-0.003	-0.003**	-0.005***	-0.002	-0.004*	-0.003	-0.004**
Eurostoxx50(1)	1.656**	2.957***	2.209***	2.696***	1.967**	1.405*	2.191***
Crisis (2)	0.034***	0.012	0.011	0.015*	0.008	0.011	0.008
Euribor3m (2)	0.000	0.000	0.000	-0.000	-0.000	-0.000	0.000
Euro/dollar (2)	-0.178	-0.410***	-0.505***	-0.178	-0.230*	-0.277**	-0.237
10yUS (2)	-0.001***	-0.001	-0.001***	-0.001*	-0.000	-0.001**	-0.001
Eurostoxx50(2)	0.494***	0.773***	0.537***	0.624***	0.701***	0.657***	0.686***
Probabilities 1							
Outcome (0)	0.917	0.916	0.914	0.915	0.914	0.914	0.913
Outcome (1)	0.067	0.071	0.073	0.073	0.074	0.073	0.075
Outcome (2)	0.016	0.013	0.013	0.012	0.012	0.013	0.012
Probabilities 2							
Outcome (0)	0.932	0.934	0.931	0.927	0.923	0.929	0.926
Outcome (1)	0.061	0.058	0.061	0.065	0.071	0.064	0.065
Outcome (2)	0.007	0.008	0.008	0.008	0.006	0.007	0.009

***, **, * Significance at the 1%, 5% and 10% levels, respectively.

Source: Estimation of the authors.

Table 4b. Marginal effects and probabilities of outcomes for the pairwise Macedonian and leading developed stock markets

	MBI DAX	MBI CAC	MBI FTSE	MBI DOW
Crisis (1)	0.053***	0.055 ***	0.058***	0.077***
Euribor3m (1)	-0.001	0.001	0.000	0.000
Euro/dollar (1)	-2.219***	-2.504***	-2.419***	-1.724***
10yUS (1)	-0.005**	-0.004**	-0.004**	-0.003*
Eurostoxx50(1)	4.177***	3.330***	3.500***	3.949***
Crisis (2)	0.005	0.005	0.010	0.017**
Euribor3m (2)	-0.000	-0.000	-0.000	-0.000
Euro/dollar (2)	-0.287**	-0.255**	-0.196**	-0.256**
10yUS (2)	-0.001**	-0.001***	-0.001***	-0.000
Eurostoxx50(2)	0.440**	0.454***	0.379**	0.424**
Probabilities 1				
Outcome (0)	0.911	0.912	0.911	0.912
Outcome (1)	0.081	0.079	0.080	0.079
Outcome (2)	0.008	0.009	0.009	0.010
Probabilities 2				
Outcome (0)	0.924	0.924	0.924	0.927
Outcome (1)	0.071	0.071	0.071	0.067
Outcome (2)	0.005	0.005	0.005	0.006

***, **, * Significance at the 1%, 5% and 10% levels, respectively.

Source: Estimation of the authors.

The probabilities observing exceedance range between 0.081 (for MBI-DAX) to 0.067 (for MBI-BELEX15), and for observing co-exceedance range between 0.016 (for MBI-BELEX15) to 0.008 (for MBI-DAX). It is important to note that these probabilities are calculated without controlling the covariates. As we previously noted, in order to separate contagion from interdependence, it is important to control for regional factors that impact all of the countries simultaneously. This reduces the probabilities of observing exceedance and co-exceedance between the pairwise stock markets. The new values of probabilities (controlled by the covariates) observing exceedance range between 0.071 (for MBI-FTSE, among others) to 0.058 (for MBI-CROBEX), and for observing co-exceedance range between 0.009 (for MBI-MONEX) to 0.005 (for MBI-FTSE, among others).

Analyzing the marginal effects of the covariates, we note that the conditional volatility of the Eurostoxx50 index has a positive significant impacts on the probability of co-exceedance in all multinomial logit models of the observed pair-wise stock markets. Accordingly, indicating that the increase in the conditional volatility of the European Union stock market increases the probability of co-exceedance (contagion) from all the observed stock markets to the Macedonian stock market. The results are in line with the findings of Dajcman (2013), Dajcman (2014) and Tevdovski (2014). Moreover, this is in line with the finance theory which suggests that stock market volatility moves counter cyclically, exhibiting spikes during recessions and tends to increase dramatically during financial crises and periods of uncertainty (Guo 2002). Furthermore, following the argument of Guo (2002) that volatility represents the systematic risk faced by investors who hold a market portfolio, which is undiversifiable, it's understandable that the rise in the systemic risk increases the beta and consequently the discount rate, thus making investments less profitable (lower returns).

The 10-year US Treasury note, shows a statistically significant impact on the probability of co-exceedance in all the pairwise stock markets, except for the MBI-DOW, MBI-CROBEX, MBI-SBITOP and MBI-MONEX. More specifically, the increase in the yield of the 10-year US Treasury note decreases the probability of observing co-exceedance (contagion) from the Serbian, Romanian, Bosnian, Bulgarian, German, French and UK stock market to the Macedonian stock market. The results are in line with the findings of Dajcman (2014), who found that the increase of the 10-year US treasury yield decreases the probability of observing co-exceedance in the Croatian stock market. Moreover, the results are also in line with the economic logic, since there is usually an inverse relation between stock market performance and the US-treasury yields. Hence, during "good times" stock market performance is better while bond yield is higher, while during uncertainty and recession the opposite happens. This is since, there is an inverse relation between yield and bond price. Hence, when demand is high and Treasury prices rise, yields fall—conversely, when demand is low Treasury prices fall and yields rise. Demand for Treasury bonds increases during uncertainty and recession, since investors are risk averse (Markowitz 1952) and they tend to shift money into lower risk assets which drives up their price. This is especially the case for US Treasury bonds and the US in general which is seen as a "safe haven". Hence during crisis there is also a "flight to quality", investors shift out of risky markets into safer ones as well across financial assets, from stock into bonds, where bonds are seen as relatively more safe and thus higher "quality" during economic downturn. To sum up, the higher US yield, usually means that bond prices are lower, which means the economic situation is better and investors prefer riskier assets instead of bonds, thus the risk of contagion and negative co-exceedance is smaller.

Similarly, the return of the euro dollar exchange rate significantly impacts the probability of co-exceedance from the developed stock markets to the Macedonian stock market, and from the Croatian, Romanian, Slovenian and Bulgarian stock market to the Macedonian stock market. More, precisely, the appreciation of the dollar versus the euro, increases the probability of co-exceedance in the before mentioned stock markets to the Macedonian stock market. The results are in line with the findings of Dajcman (2013) who comes to this conclusion studying certain Eurozone countries, and are in line with the economic theory. The economic channel is rather similar to the case of the US treasury yield. More precisely, due to the "safe haven" position of the US dollar, during uncertain times in their domestic economies or global economic uncertainty and recession, investors' shift to US dollars i.e., there is a flight to quality (see Kaul and Sapp 2006). In the case of the Euro/Dollar exchange rate the effect can be dual, both from the depreciation of the euro, due to capital outflows from the Eurozone, and the appreciation of the US dollar through the capital inflows (buying dollars). In our context, the appreciation of the US dollar versus the euro is an indication of "bad times", worse economic performances and worse stock market performance, thus higher probability of extreme negative exceedance and contagion. From another perspective, the euro appreciation versus the dollar, decreases the probability of contagion is also logical. This since, according to the economic theory, an appreciation of the currency is usually associated with an increase in economic activity or financial inflows in the country. Hence, since the majority of the Macedonian exports are towards the Eurozone, consequently of the publicly traded companies also, it's understandable that higher growth in the Eurozone is associated with better economic prospects and lower probability of negative stock returns. Interestingly, despite the economic (trade) and financial linkage of our country, we don't find that the three-month Euribor, has a statistically significant impact on the probability of co-exceedance (contagion) in any of the pairwise stock markets, i.e., the contagion from the developed and developing stock markets to the Macedonian stock market. However, our results are in line with the findings of Dajcman (2014) who also documented that the 3-month Euribor does not have a statistically significant impact on the probability of contagion from the European stock markets to the Croatian stock market.

In order to answer the question, whether the Global Financial Crisis affects the probability of contagion from the developed and developing stock markets to the Macedonian stock market, we examine the results of the time dummy variable. As it can be seen in tables 4a and 4b, the marginal effect of the Global Financial Crisis (Crisis), are significantly different from zero in the case MBI-BELEX15, MBI-SASX and MBI-DOW stock indices. The positive signs of the coefficients indicate that the probability of contagion from the Serbian, Bosnia and Herzegovinian and United States stock market to the Macedonian increased during the Global Financial Crisis. More specifically, the probability of contagion between the Serbian and Macedonian stock market increased by 0.034%, between the Bosnia and Hercegovina and Macedonian stock market by 0.015% and between the United States and Macedonian stock market by 0.017%. Our results, in terms of Serbia-Macedonia pair, are in line with the findings of Angelovska (2017), who document that during the Global Financial Crisis the Serbian stock price changes influenced Macedonian stock prices i.e. transmission. It's important to note, that these results should be taken with caution since they might be affected/contaminated also by the idiosyncratic factors of the Macedonian stock market, related to the Euro Atlantic (NATO) integration process that coincides with the Global Financial Crisis period. Although, the initial shock from the Greek veto for the accession in the NATO alliance (03.04.2008) is partially circumvented by the time dummy period, the impact of the stall in the Euro Atlantic integration might have been longer and influenced investors' sentiment and their future expectations.

Moreover, the marginal effects in Tables 4a and 4b must be read with caution, since they are calculated at covariates' unconditional means only. As argued by Greene (2003), calculating the marginal effects at covariates' means only, can give an incomplete picture if the probabilities of the dependent variable are non-linear functions of covariates. For this reason, the response of probability estimates to the full range of values of the covariates is computed. In the figure 2 the probability estimate to the full range of values of the conditional volatility of the Eurostoxx50 index is presented. The figure reveals that relationship between the probability of co-exceedance and the conditional volatility of the Eurostoxx50 index is not linear. For example, for the MBI-SBITOP the probability of co-exceedance increases more rapidly if the conditional volatility of the Eurostoxx50 index increases more than 0.03 in a day. If conditional volatility of the Eurostoxx50 index is in the range between 0 and 0.1, the probability of co-exceedance in MBI-SBITOP drops to zero.

The response curve of the conditional volatility of the Eurostoxx50 index and the probability of coexcedance of the other pairwise stock indexes has approximately the same shape and follow the same pattern i.e. if the conditional volatility of the Eurostoxx50 index increases more that 0.03% daily the probability of coexcedance increases rapidly.

Figure 2. Co-exceedance response curves of the MBI-SBITOP returns to the full range of the conditional vollatility of Eurostoxx50 index

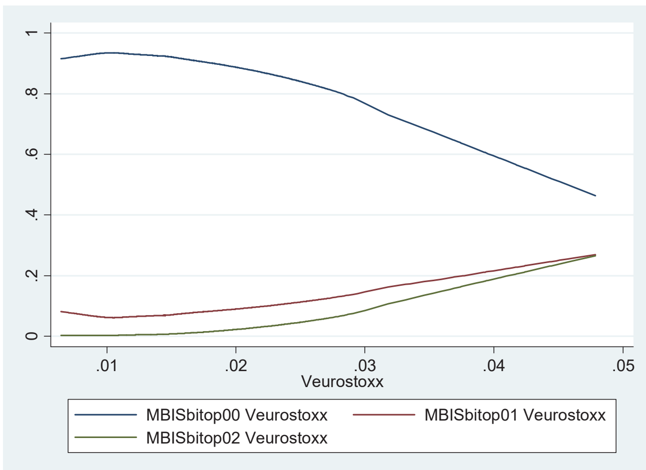


Figure 3. Co-exceedance response curves of the MBI-FTSE100 returns to the full range of the 10 year US treasury note daily change

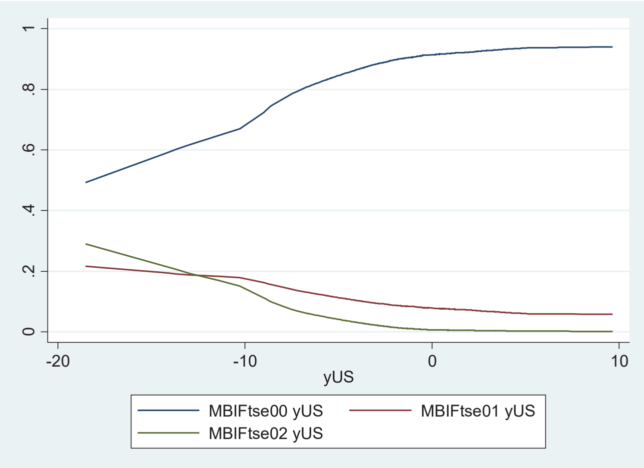
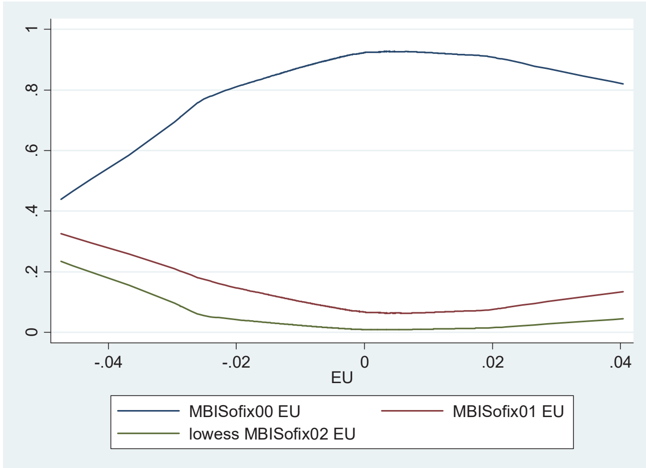


Figure 4. Co-exceedance response curves of the MBI-SOFIX returns to the full range of euro dollar exchange rate return



In figure 3, we show the response curve of the daily change of the yield of the 10-year treasury note of the USA and the probability of co-exceedance for the MBI-FTSE100. From the graph the inverse relationship is more prominent if the daily change of the yield of the 10-year US Treasury note is negative. More specifically, if the change of the 10-year US Treasury note yield decreases by more than 10% in a day, the probability of contagion increases rapidly. On the other if the daily change is positive or zero, the probability for contagion is zero. A similar pattern of movement is seen in all the other pairwise stock exchanges

Figure 4 presents the response curve of the daily log change of the euro dollar exchange rate return. The figure reveals that if the return of the euro dollar exchange rate is negative i.e. if the euro depreciates towards the dollar, the probability of co-excedance increases for the MBI-SOFIX pairwise index. It is important to note that the increase of probability for coexcedance increases rapidly (is more prominent) if the depreciation of the euro is more than 0.02% in a day. Additionally, an important fact regarding the relationship of the return of the exchange rate euro dollar and probability of coexcedance, is that the probability of coexcedance increases if there is an appreciation of dollar towards the euro by more than 0.02% in a day, but with a slower pace compared to its depreciation. The pattern of movement of the return of the euro dollar exchange rate is similar for the other pair-wise stock exchanges. It is interesting, to note that the increase of probability from the appreciation of the dollar toward the euro is more prominent in the case of MBI-BELEX15, MBI-FTSE and MBI-SAX indexes. On the other hand in the case of MBI-DAX and MBI-DOW index the probability of coexcedance is zero if the return of the euro dollar exchange rate is zero or positive.

5. Conclusion

The aim of this paper was to examine the transmission of shocks from the developed stock market and the SEE stock markets to the Macedonian stock market. We analysed the transmission of negative extreme returns from the developed stock markets and the markets of Southeastern Europe to the stock market of the Republic of North Macedonia using the method of extreme co-movements of Bae, Karolyi, and Stulz (2003).

We found a statistically significant and direct relation between the Eurostoxx50 index conditional volatility and the probability of contagion between the Macedonian stock market and the developed and developing (SEE) stock markets. On the other hand, the rise in the return of the euro dollar exchange rate and the yield of the 10-year US Treasury Note decreases the probability of contagion from the developed and the SEE countries to the stock market of Republic of North Macedonia. The results are in line with the finance and economic theory. The increase of market volatility increases beta and consequently the discount rate, thus lowers returns and increases the probability of contagion. Regarding the 10-year US Treasury note, during recessions their demand increases, since, investors tend to shift out of risky markets into safer ones as well across financial assets, and therefore yields fall, while probability of (negative co-exceedance) increases.Similar logic is also in terms of the euro dollar exchange rate which indicates that an appreciation of the dollar versus the euro, increases the probability of co-exceedance, highlighting the theory on the "safe haven" position of US dollar, and the flight to quality (towards dollars) during uncertain times in their domestic economies or global economic uncertainty (see Kaul and Sapp 2002). This is also supported by the fact that the majority of Macedonian exports is towards the Eurozone, implying that higher economic activity in Eurozone is associated with lower probability of negative stock returns. However, it's important to note that we didn't find these relations significant for all the pair-wise stocks.

We found statistically significant positive signs of the dummy Crisis coefficients, indicating that the probability of contagion from the stock markets of United States, Serbia and Bosnia and Herzegovina to the Macedonian stock market increased during the Global Financial Crisis.

These results have important implications for the possibilities of portfolio diversification. While the contagion of shocks from the stock markets of United States, Serbia, and Bosnia and Herzegovina to the Macedonian limit the possibilities for diversification, the different asset classes used as covariates in this paper can provide important signals for the investors in their portfolio decisions. These findings can be of added value especially for the Macedonian residents who are allowed to invest in foreign securities starting from January 2019, due to the entrance of North Macedonia in the second phase of the Stability and Association Agreement (SAA) with the European Union. However, we want to emphasize that these results should be taken with caution due to the idiosyncratic factors of North Macedonia, related mainly to the Euro Atlantic integrations which coincide with the crisis period and potentially had an impact on the market sentiment and the expectations of investors. Hence, for the future, research investigating whether these linkages are still present, especially during the Covid-19 pandemic could be conducted.

Endnotes

1 We follow Dajcman (2014), where the Dow Jones 30 index is used as an approximation of the US stock market.

* NOTE: The views expressed in this paper are those of the author and do not represent the views of the National Bank of the Republic of North Macedonia.

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