

## DAY-OF-THE-WEEK EFFECT IN FINANCIAL CONTAGION. THE CASE OF THE EAST-EUROPEAN MARKETS

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**ABSTRACT.** The paper analyses the day-of-the-week effect in financial contagion of the 2007-09 crisis between the US and 17 East-European stock markets (18 national indexes). Results show that the pattern is present on most of these emerging and frontier markets, but its form varies from one index to another. However, some stock markets (Hungary, Lithuania, Romania, Serbia, Slovakia) do not exhibit behavior consistent with this calendar effect.

### 1. INTRODUCTION

Financial contagion is a highly studied subject in financial literature. It has been studied in connection with most of the regional and/or global crises from history (e.g. the 1890 Argentine crisis - Bordo and Murshid, 2001; the 1997 Asian financial crisis - Abeysinghe, 2001; the 2008 Global financial Crisis - Baur, 2012; Tola and Walti, 2015; Guidolin and Pedio, 2017; the Eurozone sovereign debt crisis - Kenourgios et al, 2016). Different perspectives were proposed, either theoretical (e.g. Huang and Chen, 2018) or empirical (e.g. Sewraj et al. 2019). Studies show that different sectors from the world economy have been influenced by this phenomenon: the banking sector (Daly et al., 2019), real-economy sectors (Baur, 2012; Ashkari et al., 2017), capital markets (Ahlgren and Antell, 2010), bond markets (Tola and Walti, 2015), insurance markets (Hainaut, 2017), etc.

This broad approach has, presumably, led to the emergence of various definitions of the concept, starting with the seminal work of Forbes and Rigobon (2002) and Bekaert et al.(2005). The former view financial contagion as "a significant increase in cross-market linkages after a shock to one country (or group of countries)" while stating that a continued high market correlation is "not contagion, only interdependence". The latter define the process as "excess correlation, that is, correlation over and above what one would expect from economic fundamentals", by taking into account a factor model. Ahlgren and Antell (2010) define the concept as "significant immediate short-term transmission of shocks between financial markets in times of crisis", based on the very restrictive definition provided by the World Bank. Kenourgios et al. (2011) consider "contagion as the increase in the probability of crisis, beyond the linkages of fundamentals, and the rapid increase in comovements among markets during a crisis episode". According to Tola and Walti (2015), it is "the international transmission of country-specific shocks beyond the normal channels of financial interdependence". Mollah et al. (2016) "adopt a definition of contagion, that is, the significant increase in the conditional correlations between the pre-crisis and crisis periods".

Even though there is no uniformly accepted definition for financial contagion, some similarities can be observed. Firstly, the existence of a pre-crisis, pre-shock period which is used to define the connection between the analyzed markets in normal conditions. Additionally, a

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period of crisis is determined during which a shock develops and its impact is observed inside a country. Finally, the shock transmission to other countries or regions is studied through various channels (e.g. Guidolin and Pedio, 2017), seen as an increase of the pre-existing link between the source and the "infected" markets. The differences between the definitions can also be observed in the methodologies employed to test for the presence of financial contagion. In a novel perspective, Sewraj et al. (2019) have shown that financial contagion is not a linear process in time, being influenced by the day-of-the-week effect (hereafter, DOW). This means that the links which formed between the markets are stronger on some weekdays and weaker in others. The pattern could be attributed, at least in part, to the basic characteristics that define the relation between the analyzed markets with other external countries (import/export balances, information flows, currency regimes, announcements of macro-economic data, etc.). Another possible cause can reside in the trading behavior exhibited by the investors on the markets (short-selling, "blue Monday" effect). The authors show that, during the 2008 Global Financial Crisis (hereafter, GFC), the link between the U.S. and eleven European countries has varied extensively during weekdays. Additionally, they proved that ignoring this pattern when studying financial contagion could show misleading results, as some contagious effects could remain unobserved.

This paper uses the methodology proposed by Sewraj et al (2019) and applies it to other European countries, namely the ones from Eastern Europe. The database includes 17 markets: Bosnia and Herzegovina, Bulgaria, Croatia, Cyprus, Czechia, Hungary, Estonia, Latvia, Lithuania, North Macedonia, Poland, Romania, the Russian Federation, Serbia, Slovakia, Slovenia, Ukraine. These markets are smaller, usually younger (opened after the Communist Era from this region) and less developed than the ones from Western Europe (included in Sewraj et al, 2019). Thus, trading on these markets is reduced both in volume and trading participants. Additionally, financial literature has shown a powerful influence of calendar anomalies on the trading process in these countries (e.g. Dragotă and Țilică, 2014, Țilică, 2018, Anghel et al., 2020). For this reason, this paper investigates if similar conclusions can be reached when observing the contagion effects during the 2008 GFC.

The results could provide useful insights to active portfolio managers or investors who wish to include in their strategies, alongside the US market, Eastern European markets, seen as younger, more volatile exchanges and, therefore, capable of generating higher returns. The paper signals which markets have a weaker link to the US during turbulent periods, thus, making them better candidates for risk diversification. Additionally, specific weekdays can be targeted based on the pattern observed in the contagion process to further diminish the risk, but also benefit from the potential high return of the analyzed markets.

The rest of this paper is structured as follows: section 2 presents the database and the methodology used in the research. Section 3 discusses the empirical results and section 4 provides a brief conclusion of the findings.

## 2. DATA AND METHODOLOGICAL APPROACH

The database consists in the daily returns of 18 national indexes from 17 East-European countries and the US market, through the S&P 500 index, determined between January 2000-December 2019, as presented in Table 1. The analysis period ends in 2019 so that the results are not influenced by the COVID-19 pandemic period and the other political and economic crises that affected these countries in the following years. For seven of these indexes, the analysis period was reduced due to data unavailability (more than 10 missing consecutive trading days). However, the remaining database includes at least the returns from 2007-2009 as to contain the 2008 Global Financial Crisis.

The database includes both emerging and frontier markets, based on the classification made by FTSE, MSCI and S&P agencies. During the analyzed period, these markets have registered

TABLE 1. Descriptive statistics

Index	Country	Abbrev.	Classif.	Mean	Median	Max.	Min.	No. obs
BELEX15	Serbia	SRB	FR	-0.01%	0.00%	12.16%	-10.86%	3,712
BET	Romania	ROU	FR	0.06%	0.02%	10.56%	-13.12%	5,208
BUX	Hungary	HUN	EM	0.03%	0.00%	13.18%	-12.65%	5,208
CROBEX	Croatia	HRV	FR	0.02%	0.00%	14.78%	-10.76%	5,208
CSE	Cyprus	CYP	FR	-0.07%	0.00%	16.96%	-15.53%	3,993
MBI10	North Macedonia	MKD	FR	0.04%	0.00%	8.09%	-10.28%	3,910
MOEX	Russia-1	RUS1	EM	0.05%	0.03%	25.23%	-20.66%	5,208
OMXR	Latvia	LVA	FR	0.03%	0.00%	11.60%	-8.10%	3,979
OMXT	Estonia	EST	FR	0.04%	0.00%	12.09%	-7.87%	5,208
OMXV	Lithuania	LTU	FR	0.04%	0.01%	11.00%	-11.94%	5,208
PFTS	Ukraine	UKR	STD	0.05%	0.00%	24.43%	-15.48%	5,208
PX	Czechia	CZE	EM	0.02%	0.01%	12.36%	-16.19%	5,208
RTS	Russia-2	RUS2	EM	0.04%	0.05%	20.20%	-21.20%	5,208
SASX10	Bosnia and Herzegovina	BIH	STD	-0.01%	0.00%	9.33%	-41.37%	4,231
SAX	Slovakia	SVK	FR	0.03%	0.00%	11.88%	-14.81%	5,208
SBITOP	Slovenia	SVN	FR	0.00%	0.00%	8.36%	-8.43%	3,582
SOFIX	Bulgaria	BGR	STD	0.03%	0.00%	21.07%	-20.90%	5,004
WIG20	Poland	POL	EM	0.00%	0.00%	8.15%	-8.44%	5,208

*Note:* Classif. refers to the classification of the stock market based on FTSE, S&P, and MSCI agencies: EM = emerging market, FR = frontier market, STD = standalone, as in the case of Bulgaria, Bosnia and Herzegovina, and Ukraine in the MSCI rankings. Poland was later classified as a developed market but was considered an emerging market during the 2008 crisis.

periods with high variability, with the indices from Cyprus, Ukraine, Bulgaria and Russia registering some of the highest and lowest daily returns. Additionally, Czechia and Bosnia and Herzegovina register significantly negative returns.

The methodological approach, based on Sewraj et al. (2019), has the following general form:

$$\begin{aligned}
R_{i,t} = & \alpha_i + \alpha_{i,2} \times D_2 + \alpha_{i,3} \times D_3 + \alpha_{i,4} \times D_4 + \alpha_{i,5} \times D_5 + \beta_i \times R_{US,t} + \beta_{i,2} \times D_2 \times R_{US,t} \\
& + \beta_{i,3} \times D_3 \times R_{US,t} + \beta_{i,4} \times D_4 \times R_{US,t} + \beta_{i,5} \times D_5 \times R_{US,t} \\
& + \alpha_i^* \times D_{cr} + \alpha_{i,2}^* \times D_2 \times D_{cr} + \alpha_{i,3}^* \times D_3 \times D_{cr} + \alpha_{i,4}^* \times D_4 \times D_{cr} \\
& + \alpha_{i,5}^* \times D_5 \times D_{cr} + \beta_i^* \times R_{US,t} \times D_{cr} + \beta_{i,2}^* \times D_2 \times R_{US,t} \times D_{cr} \\
& + \beta_{i,3}^* \times D_3 \times R_{US,t} \times D_{cr} + \beta_{i,4}^* \times D_4 \times R_{US,t} \times D_{cr} + \beta_{i,5}^* \times D_5 \times R_{US,t} \times D_{cr} + \varepsilon_t
\end{aligned}$$

where  $R_{i,t}$  is the return of the national index  $i$  at time  $t$ ,  $R_{US,t}$  is the return of the S&P 500 index at time  $t$ ,  $D_{cr}$  is a dummy variable that takes the value 1 during the crisis period and 0 otherwise,  $D_2$  to  $D_5$  are dummy variables that take the value 1 in their specific week-days and 0 otherwise. The crisis days are considered to be the days from the 2007–2009 interval when the US market (represented by the S&P 500 index) registered a high volatility. For this, a GARCH(1,1) framework was used, which showed that the crisis period is between June, 9th, 2008 and Aug, 5th, 2009.

$\alpha_i$  represents the average return on non-crisis Mondays, while  $\alpha_{i,2}$  to  $\alpha_{i,5}$  are the intercept for remaining days of the week, relative to Mondays.  $\beta_i$  show spillovers from US to country  $i$  on non-crisis Mondays and  $\beta_{i,2}$  to  $\beta_{i,5}$  are additional effects seen in the rest of the non-crisis week-days, relative to Mondays. Parameters with asterisks:  $\alpha_i^*$ ,  $\alpha_{i,2}^*$  to  $\alpha_{i,5}^*$ ,  $\beta_i^*$  and  $\beta_{i,2}^*$  to  $\beta_{i,5}^*$ , show the additional effects observed during the crisis period, compared to the non-crisis period.

Due to the presence of heteroskedasticity, a GJR-GARCH framework was used, as proposed by Glosten et al. (1993), which includes the hypothesis of an asymmetrical response to positive and negative shocks. Brailsford and Faff (1996) showed that it is one of the best suited models to forecast volatility on stock markets, especially during crisis periods. Additionally, the non-normality of residuals was taken into account by using a t-student distribution and their

autocorrelation was corrected by employing an ARMA process of the appropriated rank. By employing an ARCH LM test, no additional ARCH effects were detected.

Based on this model, the DOW effect is present in financial contagion if either of the two following conditions is met: (i) contagion is present during crisis Mondays ( $\beta_i^* > 0$ ) and the behavior changed on any of the remaining weekdays (at least one of  $\beta_{i,2}^*$  to  $\beta_{i,5}^* \neq 0$ ) or (ii) contagion is not present on crisis Mondays ( $\beta_i^* \leq 0$ ), but the behavior changed in either of the remaining weekdays, leading to a positive effect ( $\beta_i^*$  plus at least one of  $\beta_{i,2}^*$  to  $\beta_{i,5}^* > 0$ ). This would show that non-Mondays spillovers during crisis ( $\beta_i^*$  plus one of  $\beta_{i,2}^*$  to  $\beta_{i,5}^*$ ) are higher than spillovers from non-crisis days ( $\beta_i$  plus one of  $\beta_{i,2}$  to  $\beta_{i,5}$ ).

### 3. RESULTS AND DISCUSSION

Table 2 shows the results for the East-European markets that were classified as emerging during the analysis period: Hungary, Czechia, the Russian Federation and Poland. In Hungary, financial contagion is observed during the 2007-2009 crisis  $\beta_i^* > 0$ , but the process has not changed significantly across the weekdays, suggesting that a DOW effect is not present. In Poland, results suggest that spillovers from the US markets are normal during non-crisis periods, but their pattern has not changed during the crisis period. Similar strong spillovers in the non-crisis periods can be observed for all of these countries.

In the Czech Republic and Russia, the calendar effect is observed through the statistically significant parameters that were obtained for both the crisis and non-crisis periods. However, a more pronounced pattern can be observed during turbulent periods. All indexes have registered positive parameters on crisis Mondays and a subsequent decrease in other weekdays (Tuesdays and Thursdays in the Czech Republic and all other weekdays for Russia).

TABLE 2. DOW effect in emerging East-European markets

Country (Index)	HUN	CZE	RUS1	RUS2	POL
$\alpha_i$	0.06%*	0.06%**	0.13%***	0.15%***	0.07%**
$\alpha_{i,2}$	-0.07%	-0.09%**	-0.08%	-0.13%**	-0.07%
$\alpha_{i,3}$	-0.01%	-0.03%	-0.10%**	-0.11%*	-0.11%**
$\alpha_{i,4}$	-0.02%	-0.01%	-0.08%*	-0.03%	-0.11%**
$\alpha_{i,5}$	-0.02%	0.00%	-0.06%	-0.06%	-0.10%**
$\beta_i$	37.53%***	30.21%***	38.49%***	41.25%***	45.62%***
$\beta_{i,2}$	-3.92%	-0.55%	-5.16%	0.11%	-2.13%
$\beta_{i,3}$	-8.70%*	-7.89%**	0.08%	0.36%	-6.97%
$\beta_{i,4}$	-2.15%	-1.72%	0.19%	11.09%*	1.59%
$\beta_{i,5}$	-8.72%*	-2.32%	2.07%	11.13%*	0.27%
$\alpha_i^*$	0.56%***	0.36%*	0.30%	0.10%	0.09%
$\alpha_{i,2}^*$	-0.91%***	-0.80%***	-1.04%***	-0.69%*	-0.15%
$\alpha_{i,3}^*$	-0.38%	0.01%	0.11%	0.14%	-0.11%
$\alpha_{i,4}^*$	-0.54%*	-0.49%*	-0.16%	0.01%	0.19%
$\alpha_{i,5}^*$	-0.70%**	-0.67%***	-0.65%	-0.48%	-0.30%
$\beta_i^*$	18.62%*	34.97%***	68.88%***	36.03%**	11.25%
$\beta_{i,2}^*$	-17.07%	-43.07%***	-76.83%***	-65.52%***	-24.75%
$\beta_{i,3}^*$	3.51%	-10.43%	-47.97%**	-44.19%**	1.58%
$\beta_{i,4}^*$	-6.81%	-30.52%*	-59.99%***	-46.40%**	-32.91%***
$\beta_{i,5}^*$	8.71%	-24.25%	-78.95%***	-63.69%*	-6.48%

Note: \*\*\*, \*\* and \* represent a 1%, 5% and 10% significance level.

Table 3 shows the results obtained for the markets classified as either frontier or standalone. During non-crisis periods, most of them show spillovers from the US market, with the exception of Bosnia-Herzegovina, North Macedonia, Slovakia and Ukraine. On the exchanges from

Cyprus, Romania and Serbia, the connection is also affected by the DOW effect. However, for all countries, the pattern observed during crisis periods is significantly different from the non-crisis one.

In Bosnia-Herzegovina and Latvia, the DOW effect is present as, even though contagion is not observed on Mondays, the spillovers increase significantly on Fridays during the crisis period. A comparable pattern can be seen in North Macedonia, when the increase is visible on Tuesdays.

In Bulgaria, the contagion phenomenon is highest on Mondays and it decreases significantly on Tuesdays, Wednesdays and Thursdays. A similar behavior is seen in the evolution of other five national indexes. In Croatia, the notable difference is that the spillovers are reduced in all other weekdays. Cyprus shows a pattern where only one weekday shows a significant decrease (on Tuesdays) as is, also, the case of Slovenia (on Wednesdays). The Estonian market is influenced by an effect that shows a high positive spillover on Mondays and a significant decrease on Wednesdays and Thursdays. In Slovenia, the pattern involves every other weekday, with the exception of Tuesday.

Lithuania, Romania, Serbia and Slovakia seem to not be affected by contagion, as the spillovers do not show a significant increase during the crisis period ( $\beta_i^*$  or either one of  $\beta_{i,2}^*$  to  $\beta_{i,5}^*$  are statistically insignificant). This does not, necessarily, show that the crisis had no impact in these countries, but it could signal that the transmission of the crisis was not directly from the US market or that the crisis period on these markets was significantly different from the one observed on the US market. This is a possible new direction of study that could be explored.

#### 4. CONCLUSION

This paper studies financial contagion during the 2007-2009 world crisis and the presence of the day-of-the-week effect in its evolution. The focus is on the spillover process from the US to 18 national indexes from East-European markets. Results show that Bosnia-Herzegovina, North Macedonia, Slovakia and Ukraine exhibited the weakest connection with the US market during non-crisis periods. However, during crisis periods, the spillover pattern changes significantly. Most countries are affected by the calendar effect, with the exception of Hungary, Poland, Lithuania, Romania, Serbia and Slovakia.

The rest of the studied countries are influenced by the DOW effect, but its pattern varies from one index to another. In Russia (both indexes) and the Czech Republic, Mondays are the days that exhibit the highest contagion with the US market. A similar pattern is also observed in Bulgaria, Croatia, Cyprus, Estonia, Slovenia and Ukraine. However, Bosnia and Herzegovina, Latvia and North Macedonia exhibit a different evolution, where contagion is higher on Tuesdays or towards the end of the week.

The results suggest that investors with internationally developed strategies can include in their portfolio Eastern European markets in order to diversify risk and benefit from the potential high returns of these highly volatile exchanges. However, they should take into account these markets' connections with the US market. For example, Poland, which has the most developed market from this region, shows a powerful link to US during both crisis and non-crisis periods. This suggests that, during turbulent times, including assets from this market could increase risk, not diversify it. However, while both the Czech Republic and Russia show a similar situation to Poland in non-crisis periods, during the crisis, the spillovers exhibit a DOW effect. Based on each specific pattern, assets from these markets could be traded in certain weekdays.

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TABLE 3. DOW effect in frontier markets

Country	BIH	BGR	HRV	CYP	EST	LVA	LTU	MKD	ROU	SRB	SVK	SVN	UKR
$\alpha_i$	-0.07%**	-0.02%	-0.08%***	-0.10%***	-0.01%	-0.09%***	-0.02%	-0.01%	0.01%	-0.05%**	0.03%	-0.03%	0.01%
$\alpha_{i,2}$	0.05%	0.02%	0.08%***	0.07%	0.03%	0.11%***	0.01%	-0.05%*	0.03%	0.03%	-0.02%	-0.01%	-0.01%
$\alpha_{i,3}$	0.06%*	0.05%*	0.14%***	0.09%**	0.05%**	0.14%***	0.06%***	0.07%***	0.05%	0.08%**	0.02%	0.04%	-0.01%
$\alpha_{i,4}$	0.09%**	0.04%	0.13%***	0.10%**	0.07%***	0.17%***	0.08%***	0.09%***	0.05%	0.12%***	0.03%	0.09%**	0.01%
$\alpha_{i,5}$	0.10%**	0.08%***	0.14%***	0.20%***	0.08%***	0.18%***	0.09%***	0.07%***	0.08%**	0.09%***	0.02%	0.13%***	0.00%
$\beta_i$	-2.30%	-0.35%	7.24%***	16.17%***	4.16%***	8.48%**	3.67%**	1.93%	17.77%***	5.95%**	3.43%	5.58%*	1.81%
$\beta_{i,2}$	0.10%	5.47%*	0.62%	-9.32%*	-2.06%	-6.45%	-0.29%	-4.31%	-11.24%***	-10.01%***	-2.24%	-2.52%	-0.60%
$\beta_{i,3}$	-1.20%	1.14%	-0.74%	-15.58%**	0.17%	-2.83%	-3.23%	-4.45%	-11.51%***	-8.75%**	-1.76%	-2.83%	-1.94%
$\beta_{i,4}$	1.14%	1.21%	-1.29%	-15.56%***	-0.86%	-0.38%	1.28%	-3.21%	-4.19%	-5.58%	-3.16%	-6.74%	3.85%
$\beta_{i,5}$	-2.14%	2.68%	0.73%	-12.78%**	3.06%	-5.93%	-1.82%	-0.77%	-6.37%	-2.77%	-5.77%	-3.00%	4.23%
$\alpha_i^*$	-0.28%***	-0.08%	0.02%	0.23%	0.07%	-0.16%	0.00%	-0.21%**	0.13%	-0.49%***	-0.15%	0.19%	0.19%
$\alpha_{i,2}^*$	-0.15%	-0.29%*	-0.35%	-0.39%	-0.02%	0.16%	-0.09%	0.15%	-0.57%**	-0.14%	-0.12%	-0.70%***	-0.58%**
$\alpha_{i,3}^*$	-0.09%	0.05%	-0.11%	-0.71%*	-0.24%	0.20%	-0.09%	-0.04%	-0.51%*	0.00%	0.05%	-0.31%*	-0.20%
$\alpha_{i,4}^*$	-0.19%	0.03%	0.18%	-0.61%	-0.72%***	-0.04%	0.06%	-0.04%	0.02%	0.16%	0.15%	-0.33%	-0.36%
$\alpha_{i,5}^*$	-0.03%	0.04%	-0.12%	-0.91%**	-0.37%**	-0.01%	-0.12%	0.05%	-0.57%*	-0.10%	0.16%	-0.18%	-0.21%
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$\beta_i^*$	-0.87%	18.54%***	45.43%***	46.68%***	13.70%**	-0.56%	6.31%	-5.87%	7.73%	8.63%	-5.53%	14.78%*	26.31%***
$\beta_{i,2}^*$	-2.52%	-18.81%**	-39.70%***	-35.39%**	-3.56%	-6.92%	-3.43%	15.20%**	3.62%	-12.42%	11.75%	-17.11%	-15.09%
$\beta_{i,3}^*$	-0.96%	-22.13%***	-32.92%***	-11.29%	-18.75%*	15.34%	-9.19%	13.01%	4.00%	-9.12%	8.36%	-25.72%***	-23.64%*
$\beta_{i,4}^*$	5.83%	-14.82%*	-20.51%*	-15.25%	-17.74%**	-19.28%**	-6.50%	4.93%	1.64%	-0.30%	11.79%	-12.41%	-28.00%**
$\beta_{i,5}^*$	14.31%*	-16.08%	-32.34%	-2.46%	24.89%*	-1.33%	-1.52%	-0.96%	5.83%	0.81%	-15.80%	-42.65%***	

Note: \*\*\*, \*\* and \* represent a 1%, 5% and 10% significance level.

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