

# TOWARD THE "NEW NORMAL" AFTER COVID-19 – A POST-TRANSITION ECONOMY PERSPECTIVE

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# 6. International portfolio diversification during the Covid-19 onset: A study of correlations among CEE post-transition and developed countries



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## Abstract

**Purpose:** The chapter examines the hypothesis that during the Covid-19 onset, the higher positive correlations between stock exchange indices persist, preventing the use of international diversification to reduce the volatility of global portfolio.

**Design/methodology/approach:** The study focuses on CEE post-transition countries and their main stock exchange indices' correlations with developed markets stock exchange indices. The data cover the period starting from January 8, 2004, until the end of October, 2020. The bivariate relationship between stock indices and VIX was measured by the Pearson coefficient of correlation.

**Findings:** The findings of correlations estimation in three periods (long-term, Covid-19 onset, and recovery) indicate that except for a period of large volatility measured by the VIX index lower relationships between developed and emerging stock markets persist. However, the results of the study concerning the shaping of correlation between the stock indices and the global risk shows a significant negative relationship between them, approaching very high levels close to 1 during the Covid-19 onset. All the CEE stock exchanges – even those low correlated in the longer term – behaved very similarly during the stock exchange crunch with its epicenter in March 2020.

**Practical implications:** The answer to the research questions concerning the shaping of correlations on international markets is important for the portfolio theory itself in its internation-

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al aspect, but also from the viewpoint of its applicability in practice. Huge market synchronization in terms of co-movements in stock indices is troubling. It significantly reduces or even eliminates the benefits of international diversification during market crashes.

**Originality and value:** Through the verification of the research hypothesis, this paper attempts to contribute to the broader literature on international portfolio diversification by delivering evidence on its limitations during the Covid-19 pandemic due to the herd behavior of investors leading to almost perfect correlations among stock exchanges.

**Keywords:** international portfolio theory, COVID-19 crash, international diversification.

## 6.1. Introduction

The Covid-19 pandemic and the actions taken to quell it led to economic turmoil in the world and contributed to the stock market crash. The crash began with series of declines in stock markets that began the February 20 and ended on April 6, 2020, when all 30 components of the Dow Jones Industrial Average (DJI) ended in the green starting its recovery that led to new historical record levels in November 2020.

The 2020 stock market crash was the fastest and most devastating fall in the global stock market since 1929. March 16 brought more than a 10% drop of indices in many countries. A characteristic feature of this period was the herd behavior of investors. As a result, the indices moved in waves, emphasizing the interconnect-edness of the world economy.

The aim of the study is to investigate correlations between domestic assets (represented by stock exchange indices in CEE post-transition countries) and foreign assets (represented by changes in selected global exchange indices) in three periods. Besides a long-term perspective covering the period from January 7, 2004, to October 30, 2020, we paid special attention to the stock market Corona-virus Crash of 2020 (February 20 to April 7, 2020) and the recovery period after the crash until the end of October, 2020. Additionally, this chapter compares interdependencies among stock exchanges in the analyzed periods with the CBOE Volatility Index (VIX), which represents investors' expectations for volatility of S&P500 index as a proxy for global risk.

Referring to studies on increased correlations among stock exchanges in the periods of crises, we assume a hypothesis that during the Coronavirus crash the higher positive correlations between stock exchange indices persist, preventing the use of international diversification to reduce the volatility of a global portfolio. If correlations between domestic and foreign markets grow in periods of increased risk (e.g. during panic related to the spread of the Covid-19 pandemic), this means a reduction in benefits of international diversification, making it even useless in

high risk times. In relation to classic explanations related to e.g. restrictions on capital flows between countries, transaction costs, or exchange rate risk, such an observation would give an additional argument in explaining the phenomenon of home bias (Black, 1974; French & Poterba, 1991), which takes place in the international stock market especially in periods of economic turbulences, thus crowding out capital from foreign markets home. However, the research questions go further. For instance, it is intriguing how the correlations are shaped in the period of recovery after crises and if the CEE post-transition countries are homogenous in bivariate relationships within a group and with global mature markets. Another question concerns the relationship between the studied indices and the VIX index, which could indicate that the correlations in the global capital markets depend on the perception of global risk.

Through the verification of the research hypothesis, this chapter attempts to contribute to the large literature on international portfolio diversification by delivering evidence on its limitations in times of the pandemic due to herd behavior of investors leading to almost perfect correlations among stock exchanges. In turn, the answer to the research questions concerning the shaping of correlations on international markets is important for the portfolio theory in its international aspect, but also from the point of view of its applicability in practice.

This study focuses on the CEE post-transition countries and their main stock exchange indices (Poland, WIG; Hungary, BUX; Czech Republic, PX; Slovakia, SAX; Romania, BET and Bulgaria, SOFIX) correlations with developed markets stock exchange indices represented by the S&P (the USA), DAX (Germany), FTSE-100 (the United Kingdom) and CBOE VIX index. The data cover the period from January 7, 2004, until the end of October, 2020.

This chapter is organized into five sections. After the introduction, a short literature review is presented, with section three addressing data and methodology. Section four presents the study and section five concludes the chapter.

## 6.2. Short literature review

The thesis that there is less connection between economies in different countries is the foundation of international portfolio theory (Grubel, 1968; Solnik, 1974) which is an extension of the modern portfolio theory developed by Markowitz (1952).

The international portfolio theory (IPT) assumes that the diversification of an investment portfolio consisting solely of domestic assets by adding foreign assets allows for a shift of efficient domestic portfolios toward international portfolios. Greater diversification on global markets benefits investors as international portfolios deliver a higher rate of return at a given risk, measured by standard

deviation (or lower risk at a given rate of return) compared to domestic ones. As a result, lower mutual relationships among investments in different countries can lead the international diversification to improving the mean-risk ratio of efficient portfolios.

The theoretical justification for this thesis is the occurrence of low correlations between domestic and international portfolios. This entails the practical use of the theory in international investment which in turn can explain the large share of foreign investors in trading on stock exchanges around the world. This is also the case of turnover in trading on post-transition countries stock-exchanges, dominated by foreign investors.

Empirical literature regarding international portfolio diversification (IPD) covers research exploring (i) benefits and barriers of international diversification, (ii) links between stock markets in the world, (iii) reasons for lower correlations among international portfolios, and (iv) dynamics of correlations in the globalized world.

Technically, investors benefit from international diversification as a result of increasing their inspected return in relations to their variation measured by standard deviation. A group of studies tested the benefits of diversification, by exploring mean-variance analysis proposed by Markowitz and following Solnik's experiment (Solnik, 1974). Most articles consider the benefits resulting from international diversification from the viewpoint of US investors, which should not come as a surprise, given the size of the US capital market. Such articles as e.g. Tesar's and Werner's (1995a) or Wan-Jiun, Alice, and Chiu-Chi (2009) confirm the existence of lower correlations between the US and other developed markets. The focus on interdependencies among emerging and developing countries and between them and developed markets were also the subject of research. What follows from the role of less developed economies in the construction of the international portfolio is the particular emphasis on smaller correlations between these economies and the developed ones. The examples are articles that examine the correlation coefficients in the Central and Eastern European stock markets (Egert & Kocenda, 2011; Middleton, Fifield, & Power, 2008), or in the Asian emerging markets (Worthington & Higgs, 2004; Dunis & Shannon, 2005). The general conclusion resulting from these works boils down to the statement that due to the fact that the dependencies between developed countries are higher than the dependencies between them and developing countries. This should lead to greater gains when the latter are included in the portfolio.

Although the causative factor of the more efficient mean-variance relation is the lower correlation between domestic and global stock exchanged compared with higher interdependencies among domestic assets, correlation coefficients among

stock exchanges are not stable. As shown by Solnik, Boucrelle, and Le Fur (1996), Knif, Kolari and Pynnönen (2005), or Sandoval and Franca (2011), correlations between stock markets tend to increase over time especially during periods of high volatility. The idea that volatility is the major driver of international correlation was however disputed by Longin and Solnik (2001) who express a different opinion. They state that correlations in capital world tend to increase in bear markets more than in bull markets. Thus, it is not volatility but a downward market trend, which is more responsible for instability in relationships between international markets. The rise of correlation especially in emerging markets was in turn caused by globalization process resulting in more freely capital flows between countries (Levy-Yeyati & Williams, 2011).

Another group of articles deals with barriers to international diversification. Solnik and McLeavey (2009) and Ardalan (2019) list the following limitations to benefits resulting from IPD: (i) lack of liquidity especially in less developed markets, (ii) different tax regulations, (iii) trading costs, (iv) unfamiliarity with foreign markets, (v) exchange rate risk, (vi) political risk, (vii) currency controls, (viii) market inefficiency related to unequal access to information (information asymmetries). The combination of “tangible” (organizational and legal) and “intangible” (social and cultural) barriers leads to the phenomenon of equity home bias (Cooper & Kaplanis, 1994; Tesar & Werner, 1995b; Coval & Moskowitz, 1999). The concentration of investors in domestic “home” equities is analyzed in numerous articles. The review of home bias literature is conducted by Cooper, Sercu, and Vanpée (2013).

### 6.3. Data and methodology

The dataset focuses on stock exchange indices in CEE post transition countries, corresponding stock indices in developed countries, and CBOE Volatility Index (VIX), which is globally one of the most important measures of volatility. Daily data from January 7, 2004, to October 30, 2020, were utilized. These were dictated by the availability of data for VIX index as the CBOE changed its methodology at the end 2003. Because the data panel was unbalanced – especially due to holidays some exchanges are closed on some days while others work normally – days with no quotes on all exchanges were eliminated to balance the panel. All variables are downloaded from stooq.pl online database ([www.stooq.pl](http://www.stooq.pl)). Table 1 below lists the analyzed countries and their stock exchange indices.

**Table 1. List of variables**

Country	Index	Country	Index	Country	Index
Hungary	BUX	the USA	S&P500	the USA	VIX
Czech Rep.	PX	Germany	DAX		
Romania	BET	the United Kingdom	FTSE100		
Slovakia	SAX				
Bulgaria	SOFIX				
Poland	WIG				

Source: Own elaboration.

The bivariate relationship between stock indices and VIX was measured by the Pearson correlation coefficient. The formula for Pearson linear correlation coefficient is designated as covariance standardization and has the following form:

$$r_{XY} = \frac{\sum_{t=1}^n (x_i - \bar{x})(y_j - \bar{y})}{\sqrt{\sum_{t=1}^n (x_i - \bar{x})^2 \sum_{t=1}^n (y_j - \bar{y})^2}} = \frac{C(X, Y)}{S_x S_y}$$

in which  $x$  and  $y$  denote tested indices for the linear relationship,  $\bar{x}$  and  $\bar{y}$  are the sample means of  $x$  and  $y$ ,  $t$  refers to the number of observations over time. In other words, the formula for Pearson's linear correlation coefficient is determined by covariance standardization. Covariance between the variables  $C(X, Y)$  is normalized by the product of their standard deviations ( $S_x S_y$ ). The significance of the correlation coefficients is tested with the test statistics,  $z$ :

$$z = \frac{r_{XY}}{\sqrt{1 - r_{XY}^2}} \sqrt{n}$$

in which the null hypothesis states  $H_0: q = 0$ , as opposed the alternative hypothesis:  $H_a: q \neq 0$ . The null hypothesis is rejected if the  $p$ -value is less than the significant level ( $\alpha < 0.05$ ).

The analysis carried out in this chapter covers three periods: (i) the entire period (January 7, 2004, to October 30, 2020), (ii) the period of the stock market crash related to the spread of Covid-19 in the world and the introduction of lockdowns in

many developed countries (February 20 to April 7, 2020), and (iii) the period after the so-called Covid-19 shock (April 8, to October 30, 2020). Descriptive statistics of the indices are presented in Tables 2 and 3.

**Table 2. Descriptive statistics of the variables  
(January 7, 2004, to October 30, 2020)**

	<i>BET</i>	<i>BUX</i>	<i>PX</i>	<i>SAX</i>	<i>SOFIX</i>	<i>WIG</i>	<i>DAX</i>	<i>FTSE</i>	<i>S&amp;P</i>	<i>VIX</i>
<i>Mean</i>	6 475	24 021	1 108	303.7	620.6	46 177	8 229	6 047	1 748	18.9
<i>Median</i>	6 648	22069	1 031	313.3	520.1	47 453	7 512	6 069	1 461	15.95
<i>Maximum</i>	10 795	46 182	1936	501.3	1 952	67 529	13 789	7 880	3 581	82.69
<i>Minimum</i>	1 880	9 461	628.5	160.2	260	21 274	3 658	3 479	676.5	9.15
<i>Std. Dev.</i>	1 897	8 562	259.8	86.34	317.7	11 095	2 880	918.2	666.6	9.272
<i>Skewness</i>	-0.23	0.738	1.213	0.235	1.85	-0.45	0.253	-0.3	0.787	2.602
<i>Kurtosis</i>	2.399	2.662	3.949	1.896	6.322	2.476	1.769	2.436	2.5	12.09
<i>Jarque-Bera</i>	86.62	349.3	1 035	219.8	3772	165.5	270.2	104.3	415.7	16 733
<i>Probability</i>	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
<i>Observations</i>	3 660	3 660	3 660	3 660	3 660	3 660	3 660	3 660	3 660	3 660

Source: Own elaboration.

**Table 3. Descriptive statistics of the variables (February 20 to April 7, 2020)**

	<i>BET</i>	<i>BUX</i>	<i>PX</i>	<i>SAX</i>	<i>SOFIX</i>	<i>WIG</i>	<i>DAX</i>	<i>FTSE</i>	<i>S&amp;P</i>	<i>VIX</i>
<i>Mean</i>	8 349	36 257	868.8	338.2	470	44 958	10 544	5 927	2 736	50.68
<i>Median</i>	7 882	32 994	815.7	335.9	433.4	41 625	10 001	5 636	2 659	53.54
<i>Maximum</i>	10 144	45 792	1 097	358	552.2	57 693	13 664	7 405	3 373	82.69
<i>Minimum</i>	7 039	29 464	690.4	315.7	405.8	37 164	8 442	4 907	2 237	15.56
<i>Std. Dev.</i>	1 038	5 339	122.2	14.87	58.02	6 073	1 555	749.7	314.4	17.48
<i>Skewness</i>	0.475	0.512	0.45	0.056	0.417	0.717	0.572	0.573	0.449	-0.2
<i>Kurtosis</i>	1.59	1.677	1.804	1.295	1.379	2.183	2.073	1.96	2.05	2.317
<i>Jarque-Bera</i>	3.973	3.846	3.083	4.015	4.57	3.748	2.98	3.294	2.35	0.87
<i>Probability</i>	0.137	0.146	0.214	0.134	0.102	0.154	0.225	0.193	0.309	0.647
<i>Observations</i>	33	33	33	33	33	33	33	33	33	33

Source: Own elaboration.



**Table 4. Descriptive statistics of the variables (April 8, to October 30, 2020)**

	<i>BET</i>	<i>BUX</i>	<i>PX</i>	<i>SAX</i>	<i>SOFIX</i>	<i>WIG</i>	<i>DAX</i>	<i>FTSE</i>	<i>S&amp;P</i>	<i>VIX</i>
<i>Mean</i>	8 660	34 932	896.5	344	440.2	49 409	12 331	6 008	3 212	28.84
<i>Median</i>	8 706	35 051	901.2	338.9	438.2	50 104	12 618	6 020	3 246	27.78
<i>Maximum</i>	9 368	38 061	957.6	372	467.2	52 889	13 255	6 485	3 581	45.41
<i>Minimum</i>	7 722	31 582	825.1	319.7	420.3	43 573	10 250	5 549	2 737	21.35
<i>Std. Dev.</i>	312.9	1580	33.04	14.01	12.03	2507	845.4	183.9	207	5.05
<i>Skewness</i>	-0.61	-0.05	-0.08	0.326	0.277	-0.73	-1.18	-0.24	-0.53	1.069
<i>Kurtosis</i>	3.611	2.229	2.037	1.877	1.971	2.471	3.2	2.869	2.373	3.996
<i>Jarque-Bera</i>	9.311	2.991	4.735	8.353	6.774	11.89	27.64	1.262	7.56	27.56
<i>Probability</i>	0.010	0.224	0.094	0.015	0.034	0.003	0.000	0.532	0.023	0.000
<i>Observations</i>	119	119	119	119	119	119	119	119	119	119

Source: Own elaboration.

## 6.4. Empirical findings

The basis of international portfolio theory is that diversification opportunities exist as world stock exchanges do not move parallel with each other. In the globalized world the national economies are closely linked which can be observed in very high correlation coefficients especially among highly developed (mature) countries (Table 5). In the period from January 7, 2004, to October 30, 2020, the average correlations among DAX, S&P500, and FTSE100 were very high, ranging from 0.79 to 0.94 (Table 6).<sup>1</sup> During the Covid-19 crash, the bivariate relationships were almost perfect (0.96–0.99), showing a huge market synchronization of investors' behavior in this group of countries (Table 7). In the recovery period the correlations considerable decreased, and between FTSE100 index and S&P5000 they hardly ever occurred. Figure 1 shows average correlations in cases of the three indices. The general pattern shows very high correlations between the mature markets' indices strengthening during the crisis time but – despite the fact that

<sup>1</sup> When analyzing the correlation coefficients in the period and in the recovery periods: 20.02.2020–07.04.2020 and 08.04.2020–30.10.2020, we should remember that variables were not normally distributed in these periods, especially during the crash time (Tables 3 and 4). This can lead to the Pearson correlation coefficient to not represent the data best. Visual inspection of the scatterplots of all pairs of variables confirms, however, the linear relationship of the variables and, in principle, the absence of outliers in almost all the cases in those periods.

the developed economies are closely linked – the recovery period to create more independent price behavior of the indices, allowing for greater possibilities to use the benefits of diversification.

Smaller but still positive correlations were visible in the group of the post-transition CEE countries in 2004–2020 (Table 5). As members of European Union, CEE countries are increasingly integrated with Western Europe. Although the countries indicate strong regional links, the group is not homogenous. Much higher co-movement can be seen among WIG, BUX, and BET (0.75–0.85) compared to other CEE indices; the lowest correlation is still positive, but it amounts only to 0.1. What distinguishes CEE stock exchanges? Let us consider just two of their characteristics that show the size of market and liquidity. First, their capitalization shows that the Warsaw Stock Exchange (with WIG index) is the largest one, with USD 130.6 bln of capitalization, next come Bucharest, Budapest, and Prague with respectively USD 23.1 bln, USD 20.9 bln, and USD 20.7 bln. Bulgarian SE has USD 16.7 bln and Slovak's market capitalization is only USD 2.4 bln.<sup>2</sup> Second, stock turnover ratio which is the total value of shares traded during the period divided by the average market capitalization for the period.<sup>3</sup> In Poland and Hungary, it amounts to 33.2% and 26.4% respectively, which means medium level of that ratio. Investors trade less in Prague and Bucharest (14.6% and 7.8%), while in Sophia and Bratislava the turnover is low (1.1% and 2.3%). Looking at these data, it should come as no surprise that foreign investors dominate stock exchanges in Poland, Hungary, the Czech Republic, and Romania. They promote through their activities stock market synchronization especially among WIG, BUX, and BET indices. The small size and low liquidity in Bulgaria and Slovakia cause these markets to behave more independent due to their small attractiveness from the viewpoint of foreign investors.

However, Table 6 shows that this distinction disappeared during the pandemic. All the indices were in many cases almost perfectly correlated, as they were in developed countries. The pairwise correlations ranged from 0.79 to 0.99. After the Covid-19 crash period, the situation returned to its long-term state. Table 7 and Figure 2 confirm this observation with one exception: SOFIX and SAX were even less correlated with the other CEE stock exchanges.

The global capital market became interrelated. The CEE stock exchanges with a large share of foreign investors, except the Czech Republic, were very high

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<sup>2</sup> All data for September 2020. Source of data: <https://focus.world-exchanges.org/issue/october-2020/market-statistics> (13.11.2020) and <https://www.ceicdata.com/en/slovakia/bratislava-stock-exchange-securities-market-capitalization/market-capitalization-bsse-shares-and-units-shares> (13.11.2020).

<sup>3</sup> <https://knoema.com/atlas/topics/Economy/Financial-Sector-Capital-markets/Stocks-traded-turnover-ratio> (15.11.2020).

correlated with mature markets in the whole period ranging from 0.71 to 0.92 (see Table 5). The different behavior of PX where there were low or even negative correlations may be puzzling (between  $-0.21$  and  $0.14$ ). The different behavior of the PX index compared to WIG and BUX can be explained e.g. by the composition of that index. PX includes only 11 companies out of which only three have more than 60% share in it.<sup>4</sup> The biggest company (CEZ; 21.8% of PX share) is controlled by the Czech Ministry of Finance, and the banking sector is strongly overrepresented (40%). Low correlations between SOFIX or SAX and mature developed indices (from  $-0.07$  to  $0.17$ ) can be explained by the lack of much interest on the part of foreign investors due to the low capitalization of Bulgarian and Slovak stock market and very low turnover, which prevented the quick reconstruction of the investment portfolio.

**Table 5. Pearson correlation coefficients among analyzed indices  
(January 7, 2004, to October 30, 2020)**

	<i>BET</i>	<i>BUX</i>	<i>PX</i>	<i>SAX</i>	<i>SOFIX</i>	<i>WIG</i>	<i>DAX</i>	<i>FTSE</i>	<i>S&amp;P</i>	<i>VIX</i>
<i>BET</i>	1,00	0,79	0,48	0,46	0,52	0,84	0,73	0,81	0,72	-0,33
<i>BUX</i>	0,79	1,00	0,14	0,35	0,16	0,75	0,81	0,76	0,85	-0,19
<i>PX</i>	0,48	0,14	1,00	0,63	0,86	0,29	-0,16	0,14	-0,21	-0,20
<i>SAX</i>	0,46	0,35	0,63	1,00	0,72	0,10	0,00	0,05	0,09	0,06
<i>SOFIX</i>	0,52	0,16	0,86	0,72	1,00	0,28	-0,07	0,17	-0,07	-0,17
<i>WIG</i>	0,84	0,75	0,29	0,10	0,28	1,00	0,83	0,92	0,71	-0,34
<i>DAX</i>	0,73	0,81	-0,16	0,00*	-0,07	0,83	1,00	0,88	0,94	-0,26
<i>FTSE</i>	0,81	0,76	0,14	0,05	0,17	0,92	0,88	1,00	0,79	-0,51
<i>S&amp;P</i>	0,72	0,85	-0,21	0,09	-0,07	0,71	0,94	0,79	1,00	-0,22
<i>VIX</i>	-0,33	-0,19	-0,20	0,06	-0,17	-0,34	-0,26	-0,51	-0,22	1,00

\* – The null hypothesis, that there is no relationship between variables, was not rejected confirming that linear relationship between them does not exist.

Source: Own elaboration.

Interestingly, all these differences disappeared during the stock market crash in February–April this year. Correlation coefficients between the indices from developed countries and CEE countries approached almost 1, indicating a very high

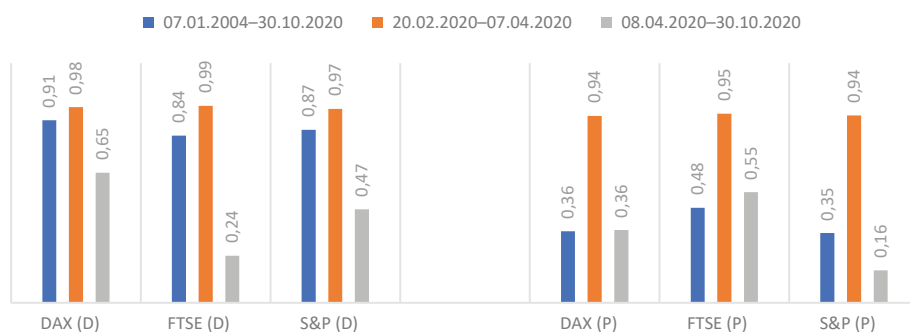
<sup>4</sup> <https://www.wienerborse.at/en/indices/index-cooperation/prague-stock-exchange/pX-profile-e/> (16.11.2020).

co-behavior (Table 6). In turn, in the recovery period, the correlations decreased (except for PX and SAX), which could indicate that foreign investors were less interested in emerging markets (Table 6 and Figures 1–2).

**Table 6. Pearson correlation coefficients among analyzed indices (February 20 to April 7, 2020)**

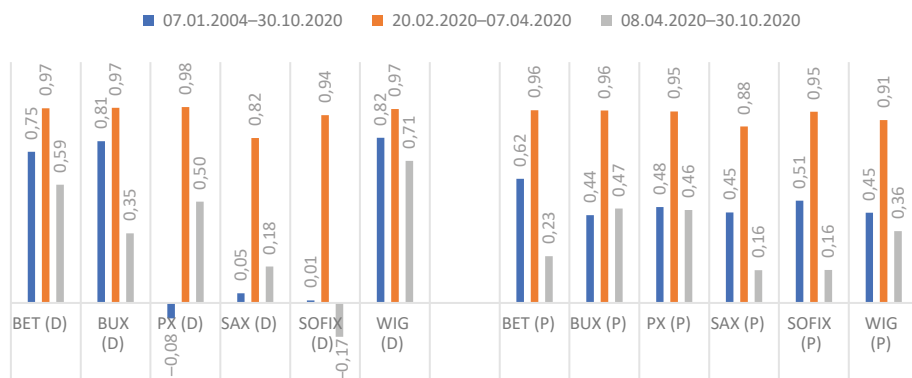
	<i>BET</i>	<i>BUX</i>	<i>PX</i>	<i>SAX</i>	<i>SOFIX</i>	<i>WIG</i>	<i>DAX</i>	<i>FTSE</i>	<i>S&amp;P</i>	<i>VIX</i>
<i>BET</i>	1,00	0,99	0,98	0,90	0,98	0,96	0,96	0,98	0,97	-0,88
<i>BUX</i>	0,99	1,00	0,99	0,89	0,97	0,95	0,97	0,98	0,97	-0,89
<i>PX</i>	0,98	0,99	1,00	0,88	0,97	0,95	0,98	0,98	0,97	-0,90
<i>SAX</i>	0,90	0,89	0,88	1,00	0,94	0,79	0,80	0,83	0,84	-0,67
<i>SOFIX</i>	0,98	0,97	0,97	0,94	1,00	0,91	0,93	0,94	0,94	-0,83
<i>WIG</i>	0,96	0,95	0,95	0,79	0,91	1,00	0,98	0,98	0,95	-0,93
<i>DAX</i>	0,96	0,97	0,98	0,80	0,93	0,98	1,00	0,99	0,96	-0,94
<i>FTSE</i>	0,98	0,98	0,98	0,83	0,94	0,98	0,99	1,00	0,98	-0,92
<i>S&amp;P</i>	0,97	0,97	0,97	0,84	0,94	0,95	0,96	0,98	1,00	-0,91
<i>VIX</i>	-0,88	-0,89	-0,90	-0,67	-0,83	-0,93	-0,94	-0,92	-0,91	1,00

Source: Own elaboration.



**Figure 1. Average correlations between individual mature capital markets indices and other developed market indices (D) or CEE post-transition market indices (P)**

Source: Own elaboration.



**Figure 2. Average correlations between individual CEE capital markets indices and developed market indices (D) or other CEE post-transition market indices (P)**

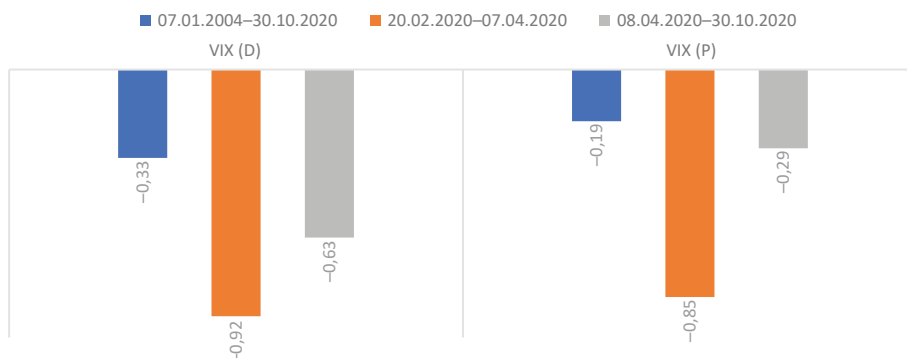
Source: Own elaboration.

The negative correlations between the VIX index and mature and post-transition markets indices indicate that there is a negative relationship between the risk index and the correlations in both groups of countries (Tables 5–7). This observation confirms a phenomenon described in the literature that during periods of high

**Table 7. Pearson correlations among analyzed indices (April 8 to October 30, 2020)**

	<i>BET</i>	<i>BUX</i>	<i>PX</i>	<i>SAX</i>	<i>SOFIX</i>	<i>WIG</i>	<i>DAX</i>	<i>FTSE</i>	<i>S&amp;P</i>	<i>VIX</i>
<i>BET</i>	1,00	0,15	0,22	0,62	-0,33	0,51	0,78	0,25	0,74	-0,55
<i>BUX</i>	0,15	1,00	0,83	0,12	0,69	0,57	0,24	0,85	-0,05	-0,30
<i>CPX</i>	0,22	0,83	1,00	0,03	0,49	0,75	0,49	0,88	0,14	-0,41
<i>SAX</i>	0,62	0,12	0,03	1,00	0,03	0,02	0,23	0,14	0,18	-0,05
<i>SOFIX</i>	-0,33	0,69	0,49	0,03	1,00	-0,05	-0,40	0,55	-0,65	0,26
<i>WIG</i>	0,51	0,57	0,75	0,02	-0,05	1,00	0,85	0,65	0,62	-0,71
<i>DAX</i>	0,78	0,24	0,49	0,23	-0,40	0,85	1,00	0,42	0,88	-0,73
<i>FTSE</i>	0,25	0,85	0,88	0,14	0,55	0,65	0,42	1,00	0,05	-0,47
<i>S&amp;P</i>	0,74	-0,05	0,14	0,18	-0,65	0,62	0,88	0,05	1,00	-0,68
<i>VIX</i>	-0,55	-0,30	-0,41	-0,05	0,26	-0,71	-0,73	-0,47	-0,68	1,00

Source: Own elaboration.



**Figure 3. Average correlations between VIX and other developed market indices (D) or CEE post-transition market indices (P)**

Source: Own elaboration.

volatility correlations between stock markets tend to increase (Figure 3). However, when analyzing the correlation indicators, one can notice a greater negative correlation between global risk and the development of indices in countries with mature capital markets than in CEE post-transition countries. This relationship occurs in principle in all three analyzed periods. The separate behavior of SAX and SOFIX, compared to other indices, is also confirmed. The correlation between these indices and the VIX index is very low or even positive, as in the case of the Bratislava stock exchange index; apart from the period of the highest volatility of the VIX, which took place during the Covid-19 crunch period.

## 6.5. Conclusions

The chapter analyzed bivariate correlations among stock indices for three mature (S&P500, FTSE100, DAX) and six post-transition CEE countries (BET, BUX, PX, SAX, SOFIX, WIG). The findings of correlations estimation in three periods (long-term, COVID-19 crash, and the following recovery) indicate that – except for a period of large volatility measured by the VIX index – lower relationships between developed and emerging stock markets persist. However, this is a case on a smaller scale than it could be expected, except for the CEE stock exchanges (Slovakia and Bulgaria) characterized by smaller capitalization and very low stock exchange turnover or by specific selection of the index (Czech Republic), which in longer-term stay low correlated with other markets.

The results of the study concerning the shaping of correlation between the stock indices and the global risk show a significant negative relationship between

them, one approaching very high level, close to 1. All the CEE stock exchanges, even those that are low correlated in the longer term, behaved very similarly during the stock exchange crunch with its epicenter in March, 2020. Huge market synchronization in terms of comovements in stock indices is bad news. As Solnik et al. (1996) notice, “when the domestic market is subject to a strong negative shock is when the benefits of international risk diversification are needed most.” Unfortunately, during that time, international portfolio theory lacks the main argument to support it: lower international correlations.

Such an observation would give also an additional argument explaining the phenomenon of home bias, which grows in the international stock market in periods of economic turbulences. After all, leaving capital abroad in periods of high global risk does not bring about diversification benefits. As a result, investors crowd out capital from foreign markets home which deepens price declines contributing to similar behavior of stock indices worldwide in times of financial turbulence.

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