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Higher Moments Actually Matter: Spillover Approach for Case of CESEE Stock Markets

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Abstract: The interconnectedness of stock markets is an important topic in empirical research, as spillovers on financial markets matter for asset pricing, portfolio allocation, financial stability, and risk management. This research focuses on all four moments of return distributions on stock markets and their spillovers between CESEE (Central, Eastern, and South-Eastern Europe) stock markets. Higher moments analysis needs to be explored more deeply, but can provide detailed insights into distribution shifts of market returns due to shocks in other markets. This research fills such a gap in the literature by estimating spillover effects between the four moments of stock market return distributions. Based on data from January 2013 to September 2022, the VAR (vector autoregression) model is estimated for individual moments across stock markets as a base for the calculation of spillover indices. The main findings indicate that it is difficult to track all the spillovers at once as the net emitter of shocks to one or other of the countries involved often change to being a net receiver and vice versa. Moreover, higher moments spillovers matter for individual markets, which has important implications for dynamic portfolio selection.

Keywords: skewness; kurtosis; stock markets; return distribution; connectedness

MSC: 91-10; 91G15; 91G45; 91G30

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1. Introduction

Successful portfolio management today is difficult in many investment-oriented businesses. This includes general investment funds, insurance-oriented companies, credit institutions, and other financial companies that have to generate profits from portfolio investing and hedge risks in their business. The connectedness between individual assets and markets has been evaluated for quite some time now (see [1], for an overview). As a result, the term spillover became prominent and is often used and examined, especially in the last decade. Generally speaking, spillovers are primarily defined in terms of return or risk shocks affecting other returns or risks. E.g., in [2], spillovers are defined as shock impacts in one asset series or one country to others due to extensive trade volume or financial linkages between them. The author of [3] defines spillovers as fluctuations in one asset price triggering changes in other asset prices. The work in[4] defines spillover for volatility series as changes of volatility in one market leading to volatility changes in others. Reasoning on why such spillovers exist has been explained in the literature: for instance, [5–7] develop a rational expectations model in which spillovers occur because of the portfolio exposures adjusting process. Meanwhile, [8] explains that increased international investment positions and portfolio inflows are some of the main reasons why return and risk spillovers matter.

Most existing research focuses on the return and risk spillovers between stocks ([9–11]), other asset classes, or between geographical markets (see Section 2.3). A much less focus has been made on spillovers between higher return distribution moments. That is why this research aims to fill this gap in the literature. Higher moments of return distribution are essential, and this is well known in both theoretical and empirical literature (see Section 2). However, much less empirical research evaluates the usefulness of higher moments in portfolio decision-making compared to the return and risk spillover analysis [12]. As investment return outcomes and their severity depend on the shape of the distribution, different shock spillovers could affect the entire distribution, not just the expected return. Moreover, previous literature recognizes that skewness can be a proxy for tail risk ([13,14]), with good predictive power for future return series [15]),. Kurtosis also has good reflective properties of tail events [16]. Thus, this research aims to empirically evaluate the shock spillovers between the first four distribution moments of stock returns of CESEE (Central, Eastern, and Southeastern Europe) markets. The primary methodological approach is the spillover index of [17,18] within the VAR (vector autoregression) model, with a dynamic estimation approach. Such an approach enables the analysis of shock spillover changes over time concerning different market and economic conditions. The results from such a study help the (potential) investors to gain insights not only into the return and risk connectedness between the stock markets for diversification purposes but to obtain a better understanding of the whole distribution changes and shifts, which is more useful in shaping the portfolio structure over time. This could be extremely helpful for the investment industry, which relies on investments where distribution characteristics in extreme events probabilities and magnitude realizations are important. Based on this discussion, a research hypothesis can be made as follows. It is assumed that higher moments of return distributions have significant spillovers between CESEE markets. This has a consequence for portfolio investing. Although the first two moments have been examined in previous literature, we extend the analysis to the third and fourth moment, as theoretical research (see Section 2.1) has shown that investor's utility function depends on higher moments as well.

There are several reasons why we focus on CESEE markets and use the abovementioned methodology. Generally speaking, CESEE stock markets are under-analyzed in the literature ([19,20]), as not only did earlier studies find diversification possibilities in these markets ([21,22]), but newer ones did as well ([23,24]), with some country-specific factors still dominating on these markets [25]. By including such markets in the international portfolio, investors could obtain better diversification possibilities, as found in [26,27]. Moreover, these markets sometimes have different reactions compared to the rest of the European or other developed markets, when looking at specific events that happen over time, e.g., the Brexit vote had somewhat mixed effects on return and volatility series [28]. Thus, international investors could find CESEE markets interesting, as including such markets in the portfolio could result in harvesting specific benefits. Moreover, as previous research did not focus on higher moments of these markets, by looking at the results obtained here, one could find potential in modeling the distributions based on information about shocks from other markets. Possible distribution changes and shifts in one market could be observed in the context of what is happening in other markets. Such analysis is lacking in existing work. Finding potential distributional shifts of one market due to shocks in other market could have effects on dynamic portfolio rebalancing over time. Although previous literature already examined return and risk spillovers, no analysis was made on the third and fourth moments, which are important as well in tracking shifts of return distributions.

The benefits of using such a methodology are twofold. Firstly, VAR models and spillover indices enable the researcher to see which markets are the emitters of shock and which are receivers. This is helpful for dynamic portfolio rebalancing. Secondly, the analysis is dynamic, making it even more beneficial for (potential) investors, as stock market changes are often abrupt. Static analysis cannot capture this, and the rolling window approach made in this paper can capture such dynamics. All of those mentioned above could be beneficial for any type of investor, to obtain information on potential sources of shocks for specific indices held in portfolios and how their distributions could change over time. That is why the second hypothesis of the paper is that spillovers between markets vary over time, meaning that static analysis is insufficient.

The main results indicate that although some countries are either net emitters or net receivers of shocks among all of the moments, there still exist those that could provide diversification possibilities for all four moments for international investors. Moreover, most shocks dissipate quickly, but some stay for some time, sometimes for all four moments. This means that shocks influence the individual distributions of stock market returns in other markets. Therefore, future forecasting of individual distributions should consider that movements in other markets often affect them. This could affect the future realized return and other higher moments that could, in turn, end up with different portfolio values than anticipated.

As a reminder, the rest of the paper is structured as follows. Section 2 gives a comprehensive literature overview of related empirical research, with data and methodology described in the Section 3. Empirical analysis is provided in Section 4, and Section 5 offers our conclusion.

2. Literature Review

Observing the literature that considers higher moments of individual asset returns or portfolios as a whole, as well as spillovers, there are several general research paths. One part of the literature introduces higher moments in portfolio optimization or asset valuation analysis. The second part empirically evaluates the size and dynamics of spillovers between return or risk series. Finally, a much smaller third path assesses spillovers of higher moments of return distributions between assets in the same market or between different markets (defined geographically or by type of asset). Given that the research literature recognized the importance of higher moments in portfolio analysis a long time ago, it is still surprising that research gaps in this area still exist.

2.1. Early Literature on Higher Order Utility Functions

As the first group of related research, it is worth covering the following papers with just a brief overview, as the methodological approaches compared to the one in this paper are quite different. However, the results are exciting and could be combined with the approach in this paper. This literature has focused on the investor's utility function optimization concerning the first four portfolio distribution moments ([29–33]). Others utilise compromise or goal programming approaches ([34–36]) or the data envelopment approach to evaluate the relative position of the portfolio compared to the best one concerning all portfolio moments ([37–39]). Some other seminal and influential work on higher moment analysis includes [40], who dealt with combining Bayesian framework into optimal portfolio selection; or [41], who found prominent spillovers for the even moments of stock and currency market return distributions. This group, in essence, analyzes the results of the optimal portfolio-weighting scheme when the stocks or assets are already selected as a broader sample to start with.

2.2. Multivariate Analyses

The second group of papers has rapidly grown in the last couple of years. It applies the spillover approach within the VAR framework, or multivariate generalized autoregressive conditional heteroskedasticity (M-GARCH) modeling, to analyze the sources, amount, and signs of the shock spillovers between return and/or risk series. Some authors examine the risk and return spillovers from a macroeconomic perspective. The author of [42] observes the 28 EU member states' stock markets over the period from 2005 to 2015 to see the general spillovers between them. Effects of the Eurozone debt crisis were observed, and the CESEE stock markets were the net receivers of shocks coming from other markets in the sample. One article ([43]) included ten developed and eleven emerging stock markets to examine the volatility spillovers in a generalized VAR approach from 2005 to 2014. This study observed intra and inter-regional spillovers. The main results indicate that domestic and regional-specific volatility shocks affect individual volatilities more than inter-regional cognation shocks. Another study ([44]) focused on the volatility spillovers between the

Latin American markets and the US (from 2003 to 2016). As expected, the spillover indices exhibit changing behavior, increasing during the financial and bond crises. GIPSI (Greek, Irish, Portuguese, Spanish, and Italian) markets were observed by [45] with the spillover index and network connectedness estimation approach. For the period from 2002 to 2016, the authors obtained the following findings. Strong volatility spillovers exist between the GIPSI markets, with contagion increasing in the crisis sub-periods. Risk spillovers were observed in [20] regarding the CESEE markets (Bulgaria, Croatia, Czechia, Hungary, Poland, Slovakia, Slovenia, and Ukraine, for the period from 2012 to 2019). The authors utilized the spillover index methodology to obtain information about the dynamics of the observed sample's net emitters and receivers of risk shocks. One author [46] has applied the spillover index methodology for the eleven selected CESEE markets to evaluate the sources of shock spillovers between them. The research aimed to obtain insights for good portfolio rebalancing over time so that interested investors could maximize portfolio values based on the results. Asymmetry has also been examined within this research, as literature has recognized the good and bad volatility as two different aspects of the risk series ([1,14,47–49]). Newer studies include the specifics of the COVID-19 period in the return and risk spillovers (such as [50–52] or [53], who still find diversification possibilities on CESEE markets). This second group of research answers many questions, such as which market (geographically, asset class, etc.) is the originator of shocks and the net emitter overall, alongside which market is the net receiver of shocks over time. Moreover, most existing work focuses on developed markets and spillovers between them. However, this overview tried to focus on the research that focuses on the related markets.

2.3. *Empirical Higher-Order Moments Analyses*

The third group of related research observes the spillovers of higher moments of return distributions. Much less literature is found here, with the majority focusing on spillovers between different asset classes. The reasoning for this could be found in the fact that the geographical spillovers for the return and risk series were very much exploited in previous research, alongside some asset classes were found to be safe havens or have good diversification properties when added to general portfolios. Again, the VAR methodology is the basis for most research, with factor or time-varying models being some of the specifics utilized in the empirical analysis.

Two similar studies are [41,54]. The first paper uses intraday data on eighteen markets to evaluate the spillovers of skewness and kurtosis within selected regions (Asian Pacific, Western Europe, and Latin America; period: 2002 to 2009). Here, the authors found a positive bi-directional relationship between volatility spillovers and a negative one for the skewness between the stock and FX markets. In the second study, the same authors extend their analysis (to 27 markets), the period (1997 to 2010), and the sub-regions (e.g., Europe was divided into the North, South, and Western). The spillovers were more significant in the case of developed markets. It was observed in [55] that gold and oil return moments to test causality between them. For a long period (from 1997 to 2017), the authors observed the results of the time-varying causality test for the return, realized volatility, skewness, kurtosis, and volatility jumps. The main results indicated no spillovers between return series but significant spillovers regarding other moments, with kurtosis spillovers particularly strong. This result means that greater spillover exists during extreme market movements. Another study ([56]) applied the causality testing within the VAR approach for the Bitcoin, gold, and crude oil return distributions to examine the spillover effects of jumps and the second, third, and fourth moments. All moments have been found to have significant spillovers among the different asset classes in the observed period (from 2014 to 2018). The authors of [57] have focused on the US, UK, German, and Japanese stock markets to evaluate the volatility and skewness risk premium spillovers between them and within each market. Their main findings include the presence of greater between–markets and between–moments spillovers during higher stress periods, alongside significant spillovers between volatility and skewness risk premiums. Ref. [58] focused on three big cryptocurrencies (Bitcoin, Ethereum, and Litecoin) and their higher moment connectedness. Based on spillover indices within the VAR model, the main conclusions from the analysis are that the higher moments of these cryptocurrencies are priced in the cross-section of their returns. This means that not only are the higher moments essential for investors, but their spillovers are essential among currencies as well. Higher-moment spillovers between the stock and commodity markets have been explored in [12]. Based on daily data from 2018 to the end of 2020, the authors conducted a time-varying VAR approach for the case of Chinese data and markets. The authors found that the observed assets are linked not only via the return series but also by higher moments dynamics. The overall spillover is greatly affected by the economic uncertainty and the US stock market dynamics, alongside the COVID-19 sub-period. The authors of [59] examine the return-volatility, -skewness, and -kurtosis relationships for the case of crude oil returns on the US market. Here, the authors focus on the spillovers between the moments of the same asset, finding proof of the skewness preference theory, fundamental theories, and extrapolation bias.

The main observations that can be concluded from the related literature are as follows: (1) the ever-changing dynamics of financial markets cause the relationships and spillovers between individual assets, asset classes, and geographical markets' return distribution moments; and (2) although the results are not uniform, the majority of spillover values increase during greater stress, i.e., during bull markets, though only some specific markets and assets have been observed. However, markets such as the CESEE ones have still not been explored enough, as higher moments analysis is still missing from the author's knowledge.

3. Data and Methodology Description

3.1. Data Description

For the purpose of empirical analysis, daily data on the index series was collected from [60] for the following countries: Bosnia and Herzegovina (BiH), Bulgaria, Croatia, Czechia, Poland, Romania, Serbia, Slovakia, and Slovenia. Other CESEE countries that are not included here do not have enough data available to be included in the analysis. To obtain as much data as possible (both the time and cross-section perspective), the resulting sample starts on 10 January 2013, and ends on 9 September 2022. Monthly average return, variance, skewness, and kurtosis were calculated to evaluate the spillovers between all four moments of return distributions. The average return was calculated as an ordinary average of all daily return series, and variance was calculated based on the average monthly return and individual daily returns, representing the average deviation of daily returns from the average monthly return. Skewness and kurtosis were estimated as average deviations of daily returns from the average monthly return, with respect to the third and fourth power of those deviations.

To serve as control variables, we collected the following: the European EPU index was collected from [61], the shadow rate for the ECB from [62], and the German VIX from [63]. The EPU index was previously found to be a significant factor in affecting the dynamics of stock markets in Europe and CESEE countries, as seen in [12,64–68]. The effects of monetary policy on stock market dynamics have been significant for a long time now (see [69–72]). Finally, the VIX series is extensively included in empirical research that finds significant interactions between VIX and risk and return series for many countries ([73–75]). The EPU and shadow rate have been differenced on a year-to-year basis, making all of the variables in the models stationary. For every moment of the distribution (mean return, standard deviation, skewness, and kurtosis), a VAR model is estimated on monthly data among CESEE markets, with the three variables (year-on-year change of EPU and shadow rate, and VIX) included as exogeneous. Descriptive statistics of every variable and figures are shown in Appendix A.

3.2. Spillover Index Methodology

Spillover indices of [17,18] are an extension of the VAR methodology. We observe a stable VAR(p) model where the p is the number of lags of endogenous variables in the system. If the model is written in the matrix form [76–80], it can be written as follows: $\boldsymbol{y}_t = \boldsymbol{v} + \boldsymbol{A}_1\boldsymbol{y}_{t-1} + \boldsymbol{A}_2\boldsymbol{y}_{t-2} + \ldots + \boldsymbol{A}_p\boldsymbol{y}_{t-p} + \boldsymbol{\varepsilon}_t$, where $\boldsymbol{y}_t$ represents a $(N{\cdot}1)$ vector of dependent variables, $\boldsymbol{A}_i$ represents $(N{\cdot}N)$ coefficient matrices, $i \in \{1, 2, \ldots, p\}$, $\boldsymbol{v}$ the $(N{\cdot}1)$ vector of intercepts, and $\boldsymbol{\varepsilon}_t$the $(N{\cdot}1)$ white noise process vector with $E(\boldsymbol{\varepsilon}_t) = \boldsymbol{0}$, $E(\boldsymbol{\varepsilon}_t\boldsymbol{\varepsilon}_t{}') = \Sigma_\varepsilon < \infty$, and $E(\boldsymbol{\varepsilon}_t\ \boldsymbol{\varepsilon}_s{}') = 0$ for $t \neq s$. A compact form for the VAR(p) model is the following VAR(1) way of writing it:

$\boldsymbol{Y}_t = \boldsymbol{V} + \boldsymbol{A}\boldsymbol{Y}_{t-1} + \boldsymbol{e}_t$, $\boldsymbol{Y}_t = (\boldsymbol{y}_t\ \boldsymbol{y}_{t-1} \ldots \boldsymbol{y}_{t-p})'$, $\boldsymbol{V} = (\boldsymbol{v}\ \boldsymbol{0} \ldots \boldsymbol{0})'$,

$$\boldsymbol{A} = \begin{bmatrix} \boldsymbol{A}_1 & \boldsymbol{A}_2 & \ldots & \boldsymbol{A}_{p-1} & \boldsymbol{A}_p \\ \boldsymbol{I}_N & \boldsymbol{0} & \ldots & \boldsymbol{0} & \boldsymbol{0} \\ \boldsymbol{0} & \boldsymbol{I}_N & \ldots & \ldots & \ldots \\ \ldots & \ldots & \ldots & \ldots & \ldots \\ \boldsymbol{0} & \boldsymbol{0} & \ldots & \boldsymbol{I}_N & \boldsymbol{0} \end{bmatrix},\ e_t = (\boldsymbol{\varepsilon}_t\ \boldsymbol{0} \ldots \boldsymbol{0})' \tag{1}$$

i.e.,

$$\boldsymbol{Y}_t = \boldsymbol{\mu} + \sum_{i=0}^{\infty} \boldsymbol{A}^i \boldsymbol{e}_t = \boldsymbol{I_N} - \boldsymbol{A}\boldsymbol{L}^{-1}\boldsymbol{V} + \Phi_i(\boldsymbol{L})\boldsymbol{e_t} \tag{2}$$

where L denotes the lag operator, with $L^j\boldsymbol{Y}_t = \boldsymbol{Y}_{t-j}$, $j \in \mathbb{R}$, and $\Phi(L)$ denotes the polynomial such that it holds $\Phi_i(L) = \boldsymbol{j}\boldsymbol{A}^i\boldsymbol{j}\,'$, $\boldsymbol{j} = (\boldsymbol{I}_N\ \boldsymbol{0} \ldots \boldsymbol{0})$. Thus, VAR in (2) can be used to estimate the IRFs (impulse response functions) and the FEVDs (forecast error variance decompositions). As the elements in $\boldsymbol{e}$ are correlated, the Generalized IRFs are estimated, as in [81]: $GI_y(h, a_j, I_{t-1}) = E(\mathbf{Y}_{t+h} \mid e_{jt} = a_j, I_{t-1}) - E(\mathbf{Y}_{t+h} \mid I_{t-1})$, where h denotes the forecasted horizon, a_j the shock in variable j, information set I_{t-1}.

From [82] it follows that: $E(\boldsymbol{e}_t \mid e_{jt} = a_j) = (\sigma_{1j}\ \sigma_{2j} \ldots \sigma_{Nj})'\sigma_{jj}^{-1}\ \delta_j = \sum_\varepsilon u_j\sigma_{jj}^{-1}\ a_j$, where u_j is a $(N{\cdot}1)$ vector of zeros with the exception of value 1 in place j. If we set $a_j = \sqrt{\sigma_{jj}}$, the scaled j-th Generalized IRF is $\psi_j(h) = \sigma_{jj}^{-1/2}\Phi_h\sum_\varepsilon u_j$. The Generalized FEVDs are now estimated as follows:

$$\theta_{jk}(h) = \frac{\sigma_{jj}^{-1/2}\sum_{i=0}^{h-1}\left(u_j'\Phi_i\sum_\varepsilon u_k\right)^2}{u_j'\Phi_i\sum_\varepsilon\Phi_i'u_k} \tag{3}$$

From (3), we can now calculate the spillover indices, by normalizing values $\theta_{jk}\ (h)$, i.e., calculating $w_{jk}\ (h) = \theta_{jk}(h) / \sum_{k=1}^{N}\theta_{jk}(h)$ in the first step, and then calculating the total spillover index:

$$S(h) = \sum_{\substack{j,k=1 \\ j \neq k}}^{N} \theta_{jk}(h)/N{\cdot}100\% \tag{4}$$

and the individual spillover indices, including the spillover that a variable receives from other variables in the model (without its own shocks), spillovers from one variable to all others, pairwise spillovers (from one variable to another one), and the net values to determine if a variable is a net giver or receiver of shocks. Complete formulae are given in [12].

Finally, as dynamics are important to analyze in this area of research, the model and spillover indices are estimated on a fixed-length rolling window basis. The majority of literature that utilizes such an approach, such as the characteristics of markets, change these factors over time (see [20,43–45,47], or [83–85]). The length of the rolling window depends on the type of analysis and variables. For example, macroeconomic analysis usually has a longer window length, whereas financial markets analysis has shorter windows in the rolling procedure. The reasoning for this is found in faster changes in financial markets compared to transmission mechanisms of economic policies, alongside the business cycle duration. Therefore, this study uses the rolling window length of 24, 36, and 48 months. Other related literature that estimates spillovers between financial markets, specifically stock markets, has the following practice in determining the rolling window length. A

200-day (i.e., 40 weeks or ten months) length is used in one seminal paper ([12]), as well as for the case of volatility spillover in the interbank sector in [86]. A 300-day approach (60 weeks or 15 months) is found in [87], who observes spillovers in the BRICS stock markets. Third, a 200-weeks (i.e., 50 months) rolling window length is utilized in [11] for asset return and volatility spillovers and in [88], who focus on the spillovers within the EU fund industry. There are very short-length approaches, such as the 50-day (or two months) length in [89], which focuses on volatility spillover in the US stock market. Other applications utilize 30 months, such as [90] for a macroeconomic model or [91] for the case of stock market data "Google-ing". There are also studies with longer lengths of the rolling window, such as [92], where Euro area financial markets spillovers were examined on a 2-year (or 104 weeks, i.e., 26 months) basis. Other lengths in related studies are 100 (5 months or 20 weeks) and 150 days (alongside the already mentioned 200 days) in [48], where the US stock market's connectedness was examined. That is why this study uses a range from 24 to 48 months. This range means that shorter and longer horizons can be observed for robustness checking, capturing specific shocks, whilst retaining some degree of freedom as well.

4. Empirical Analysis

4.1. Static Results

The first part of the analysis includes the spillover table for the full sample (static analysis) for every moment of the return distribution. Tables are based on the VAR(1) model, as it was found to be sufficient to describe the dynamics and the usual tests providing evidence that the model errors were white noise. Tables 1–4 depict these tables for the return, standard deviation, skewness, and kurtosis, respectively. The bottom right cell in each table is the total spillover index, with values in the last rows and columns being average spillovers of shocks from the country i return to other countries and the average spillover value of shocks that country i return receives from other countries' return shocks. The rest of the table is the variance decomposition of each return forecast variance. All the tables highlight the highest values of spillovers from one country to another with grey cells. There are several conclusions based on the entire sample analysis in Tables 1–4. First, the greatest total spillovers are found for the mean return and risk series, and the values for the skewness and kurtosis are not negligible (more than 20%).

By focusing on Table 1, we can see that Czechia, Slovenia, and Poland received the majority of shocks from other countries. The best diversification possibility is found for Bosnia (BiH) and Slovakia as those countries received the lowest number of shocks from other countries. Based on the grey-shaded cells, an investor could consider not giving greater weight to those countries whose return shocks spill over to those that primarily receive them, or vice versa. This also indicates that the mean return in some countries is affected by other shocks. The most frequent receivers of shocks were Serbia and Czechia, meaning that their returns are more connected to other markets than the rest of the countries in the sample. Thus, different shocks that affect market returns in other countries could also affect those two markets. The shocks of Czechian returns also spill over to many other countries (four in total), indicating that this market is very much integrated with the majority of the countries studied here, as it both receives from and gives shocks to many of them.

Table 2 focuses on risk series, with Bosnia and Slovakia's risks being affected the least by risk shocks in other countries. Poland, Croatia, and Slovenia are those whose risks are affected significantly by risk shocks from others. Croatia and Slovenia are the greatest givers of shocks, followed by Czechia and Poland. Moreover, the width of the distribution of some countries changes due to shocks in other markets. This should also be considered when forecasting return distributions for portfolio purposes. Furthermore, this indicates which countries could be affected via contagion when markets fall. Slovenian risk shocks spillover in four countries in a greater manner, making it the local generator of shock spreading.

Skewness spillovers are shown in Table 3, where one can see that the shock spillovers are smaller compared to the first two moments. Countries whose skewness is affected significantly by shocks in others are Croatia, Poland, and Bulgaria. This means that the shifts of their distributions from one side to another, or when emphasizing the already realized asymmetry, are influenced by shocks coming from other markets. On the opposite side, Serbia, Slovakia, and BiH are affected a minuscule amount by other shocks. Moreover, the countries that give surprises most often to others are Croatia and Romania. In contrast, those receiving shocks most often from other countries are Bulgaria (three countries), followed by Slovenia, Croatia, and Romania. Therefore, those mentioned as receivers of shocks, given the value of the spillovers and the number of countries that send shocks to country *i*, should consider that the skewness of return distributions is subject to shocks in country-emitters.

Finally, Table 4 depicts the results for the kurtosis series for the whole sample. Here, the most often receiving countries in terms of the value of the spillovers from others are Croatia, BiH, and Poland. Thus, extreme market movements captured in the tails of the return distributions could affect these three markets. On the opposite side, the least often receiving ones were Bulgaria, Slovakia, and Slovenia. Croatia is mainly affected by the number of countries a market receives shocks from, followed by Serbia and Romania.

Table 1. Spillover table, static analysis, mean return series.

Return	Serbia	Romania	BiH	Croatia	Czechia	Slovakia	Slovenia	Bulgaria	Poland	FROM_Average
Serbia	48.43	6.66	1.93	11.53	10.22	0.89	10.06	5.96	4.31	6.45
Romania	7.18	50.83	1.18	10.68	14.23	0.03	8.58	1.07	6.22	6.15
BiH	2.46	0.55	77.44	8.71	4.46	1.19	2.02	0.34	2.82	2.82
Croatia	9.78	9.26	3.19	45.52	8.74	0.22	11.51	4.79	6.98	6.81
Czechia	9.45	10.01	0.33	7.6	39.74	0.47	13.02	3.3	16.07	7.53
Slovakia	0.78	0.91	1.4	1.13	1.3	87.13	3.49	2.97	0.89	1.61
Slovenia	9.98	6.4	5.78	10.58	12.7	0.31	38.35	6.09	9.8	7.71
Bulgaria	8	1.27	0.91	6.91	5.05	1.19	9.83	60.04	6.8	5.00
Poland	4.02	5.23	2.41	7.25	18.53	0.95	11.93	4.72	44.96	6.88
TO_average	6.46	5.04	2.14	8.05	9.40	0.66	8.81	3.66	6.74	45.28
Net spillover	0.09	−8.88	−5.42	9.92	14.98	−7.62	8.8	−10.72	−1.15	-

Source: author's calculations. Note: FROM_average and TO_average denote average values of spillovers from other countries to country *i*, and average values of spillovers from country *i* to other countries. Net spillover is the value of spillover from country i to all other countries reduced by spillovers country i receives from others. Positive values denote that the country is a net giver of shocks, whereas negative values denote that the country is a net receiver of shocks. Shaded cells denote spillover values greater than 10 p.p.

Table 2. Spillover table, static analysis, standard deviation (SD) series.

Return	Serbia	Romania	BiH	Croatia	Czechia	Slovakia	Slovenia	Bulgaria	Poland	FROM_Average
Serbia	60.86	8.55	1.9	4.19	4.07	5.8	4.38	3.28	6.97	4.89
Romania	4.85	48.61	2	5.1	9.14	7.89	8.94	4.66	8.82	6.43
BiH	2.57	5.66	85.92	0.51	1.39	2.68	0.49	0.32	0.46	1.76
Croatia	2.08	4.6	4.15	43.13	9.48	3.56	12.93	8	12.07	7.11
Czechia	3.02	7.5	0.87	9.09	44.68	0.81	15.88	6.55	11.6	6.92
Slovakia	6.19	4.33	0.34	4.37	0.9	78.85	0.94	0.86	3.22	2.64
Slovenia	2.08	6.43	5.33	12.96	11.69	1.68	38.23	12.59	9.01	7.72
Bulgaria	2.11	5.12	2	11.01	7.02	2.45	16.57	52.79	0.92	5.90
Poland	4.78	6.86	8.64	12.35	13.45	2.28	10.47	0.62	40.54	7.43
TO_average	3.46	6.13	3.15	7.45	7.14	3.39	8.83	4.61	6.63	45.15
Net spillover	−11.46	−2.35	11.15	2.71	1.82	6	8.83	−10.32	−6.38	-

Source: author's calculations. Note: FROM_average and TO_average denote average values of spillovers from other countries to country *i*, and average values of spillovers from country *i* to other countries. Net spillover is the value of spillover from country *i* to all other countries reduced by spillovers country *i* receives from others. Positive values denote that the country is a net giver of shocks, whereas negative values denote that the country is a net receiver of shocks. Shaded cells denote spillover values greater than 10 p.p.

Table 3. Spillover table, static analysis, skewness series.

Return	Serbia	Romania	BiH	Croatia	Czechia	Slovakia	Slovenia	Bulgaria	Poland	FROM_Average
Serbia	87.71	0.79	0.41	0.9	2.06	1.21	0.84	5.26	0.82	1.54
Romania	0.25	75.69	1.01	6.39	1.09	5.58	2.66	3.36	3.97	3.04
BiH	0.41	4.02	85.26	3.61	2.22	1.26	0.34	0.64	2.25	1.84
Croatia	0.13	7.39	2.3	67.34	3.86	3.02	3.7	3.3	8.96	4.08
Czechia	1.91	1.68	1.66	3.76	84.6	0.28	1.11	0.49	4.52	1.93
Slovakia	0.76	5.7	0.64	0.12	0.61	87.04	2.57	1.91	0.64	1.62
Slovenia	2.48	4.23	0.12	5.12	1.19	0.67	76.49	6.57	3.13	2.94
Bulgaria	1.11	8.03	0.87	5.82	0.39	1.26	6.9	72.9	2.71	3.39
Poland	0.6	5.25	1.92	10.53	3.38	0.84	2.98	2.79	71.72	3.54
TO_average	0.96	4.64	1.12	4.53	1.85	1.77	2.64	3.04	3.38	21.25
Net spillover	−4.64	12.78	−5.82	3.59	−0.61	1.17	−2.41	−2.77	−1.29	-

Source: author's calculations. Note: FROM_average and TO_average denote average values of spillovers from other countries to country i, and average values of spillovers from country *i* to other countries. Net spillover is the value of spillover from country i to all other countries reduced by spillovers country *i* receives from others. Positive values denote that the country is a net giver of shocks, whereas negative values denote that the country is a net receiver of shocks. Shaded cells denote spillover values greater than 5 p.p.

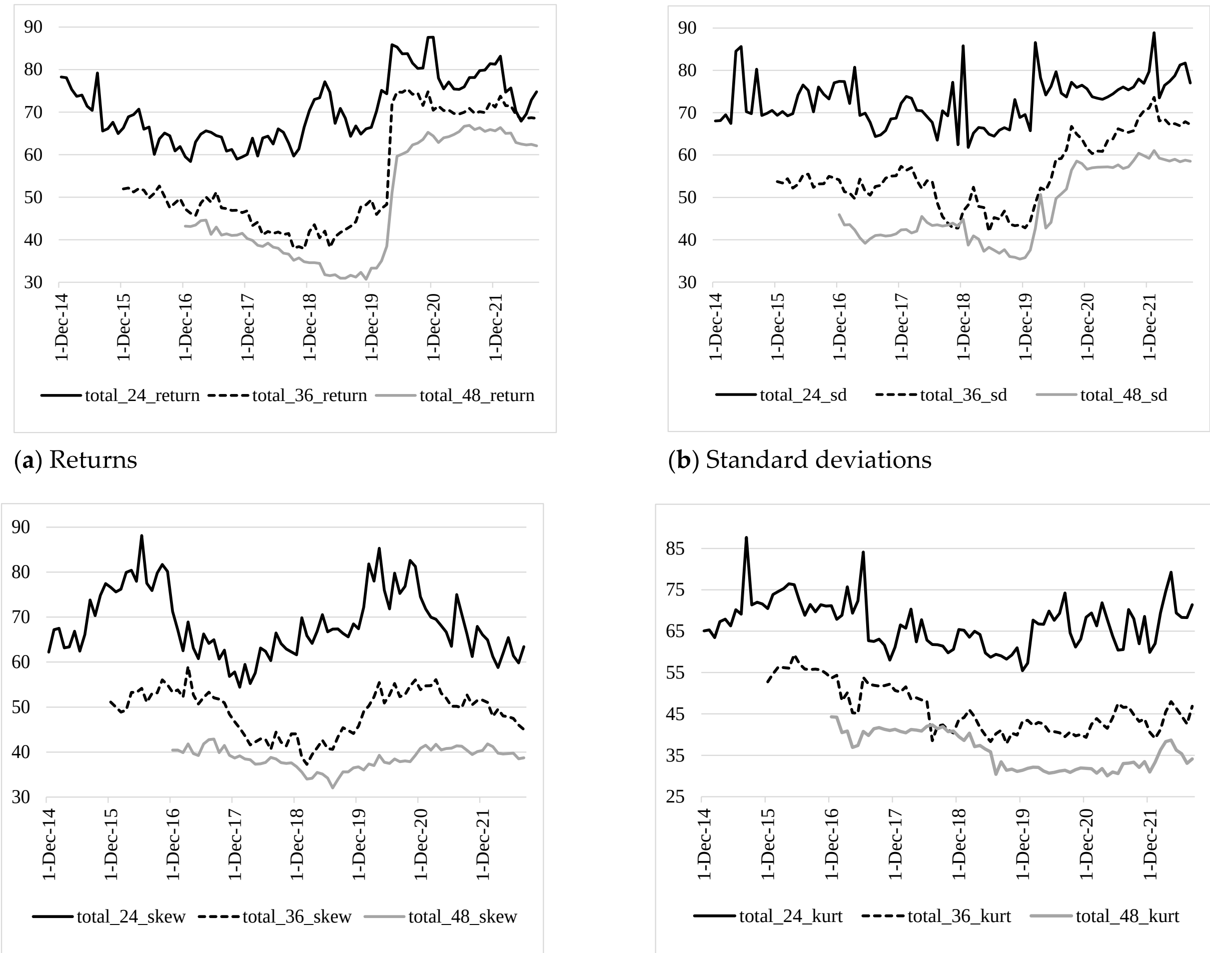
Table 4. Spillover table, static analysis, kurtosis series.

Return	Serbia	Romania	BiH	Croatia	Czechia	Slovakia	Slovenia	Bulgaria	Poland	FROM_Average
Serbia	84.6	0.68	5.36	0.82	1.66	1.46	3.6	0.59	1.23	1.93
Romania	1.31	76.85	4.56	7.84	1.76	2.49	1.82	1.52	1.86	2.90
BiH	2.88	5.59	75.15	2.78	4.6	1.13	4.16	1.02	2.69	3.11
Croatia	5.95	6.48	2.12	70.48	1.54	1.17	4.07	0.49	7.69	3.69
Czechia	6.79	0.45	4.81	1.66	79.61	0.22	0.18	1.84	4.44	2.55
Slovakia	1.04	3.08	0.31	2.34	0.64	84.72	5.15	2.15	0.57	1.91
Slovenia	3.25	0.85	0.25	5.25	2.2	3.16	84.86	0.08	0.11	1.89
Bulgaria	0.96	0.56	1.1	1.09	3.81	1.63	2.77	85.69	2.38	1.79
Poland	3.02	1.64	2.75	7.43	6.71	0.32	0.55	1.7	75.89	3.01
TO_average	3.15	2.42	2.66	3.65	2.87	1.45	2.79	1.17	2.62	20.24
Net spillover	9.8	−3.83	−3.59	−0.3	2.53	−3.7	7.15	−4.91	−3.15	-

Source: author's calculations. Note: FROM_average and TO_average denote average values of spillovers from other countries to country *i*, and average values of spillovers from country *i* to other countries. Net spillover is the value of spillover from country *i* to all other countries reduced by spillovers country *i* receives from others. Positive values denote that the country is a net giver of shocks, whereas negative values denote that the country is a net receiver of shocks. Shaded cells denote spillover values greater than 5 p.p.

4.2. Dynamic Results

When moving to the dynamic analysis, spillover indices were estimated on a rolling window basis, with three different lengths of the window: 24, 36, and 48 months. Although the value of the length is used to determine the robustness of the results, dynamics in stock markets frequently change, and longer values of the window length are somewhat different in the interpretation compared to the usual sluggish macroeconomic variables. Therefore, it could be said that the shorter the length, the more the spillover index will reflect specific shocks, and if the length is longer, it will reflect the memory of shocks, so one could obtain general trends over time if they exist. Thus, Figure 1 shows total spillover indices for the case of all four moments individually. The first two moments are affected mainly by the COVID-19 shock in the spring of 2020 due to more significant overall spillovers among the first two moments in contrast to the third and the fourth. Moreover, there had been a general decline in the spillovers of all four moments until the COVID-19 crisis. This means that the previous sub-period favored diversification possibilities among the CESEE markets. However, a mild increasing trend was only found for the case of skewness in the period from 2018 until the end of 2020. Focusing on the mid-term, i.e., the 36 months' rolling window length, skewness and kurtosis spillovers are more robust in maintaining the total spillover value compared to the first two moments. However, skewness and kurtosis should not be ignored, as the values of total indices are not small, meaning that although being almost constant, one part of individual distribution does depend on shocks from other markets in the sample. Finally, by looking at the most recent big event that could have affected the dynamics, the war in Ukraine that started in spring 2022, it is seen that the spillovers of return and standard deviation series continued increasing until the end of the sample. Asymmetry spillovers were not affected that much, but the kurtosis spillovers had an initial spike that decreased, but the total spillover still increased afterwards. This means that such events shift individual distributions, their width, and tail fatness, meaning that more extreme events could happen in future as well. These results are in line with the first findings of [93], who focused only on return series in the first quarter of 2022 and for 94 countries in the sample found a negative relationship between the war and market returns.



(**a**) Returns

(**b**) Standard deviations

(**c**) Skewness

(**d**) Kurtosis

Figure 1. Total spillover indices. Source: author's calculations. Note: total denotes the total spillover, 24, 36 and 48 denote the length of the rolling window.

For better dynamic portfolio rebalancing purposes, net spillovers for every country were calculated for the case of all four moments and are shown in Figures 2–5. Positive values of the individual indices mean that the country's moment was a net emitter of shocks. Observing such results provides insights into the possible contagion of shocks from one market to another and how this could be reflected in a portfolio. As an example, when the COVID-19 shock occurred, net emitters of shock were Serbia, Croatia, Bulgaria, Czechia, and Poland regarding return series (Figure 2); Croatia regarding risk series (Figure 3); Romania, Czechia, Bulgaria, and Poland regarding skewness (Figure 4); and Slovakia and

Bulgaria regarding kurtosis (Figure 5). Moreover, specific shocks in a country can be tracked via Figures 2–5 to see if it spills over to other series of interest and by how much. Next, frequent and sometimes abrupt changes in the values of net indices show that shocks that occur in stock markets often have short-term effects and sometimes with high magnitudes. Some shocks dissipate quickly (seen in spikes of net spillovers in all Figures), meaning that they do not affect the distribution in the longer term. Other shocks stay for longer in some series (when the net index is generally negative for some time), which may affect the shape of the distribution, e.g., the Slovakian mean return series (Figure 2, last row) has a negative trend in the observed period, meaning that this market has been receiving shocks from others over time, and the mean return is under the influence of shocks in the return series on other CESEE markets. Finally, co-movements of net spillovers can be tracked over time to see when some markets are emitters and which ones are the receivers simultaneously. As an example, the net spillovers of the kurtosis series in Figure 5 show that since 2021, shocks in Serbia, Croatia, and to a lesser extent in Slovakia and Bulgaria were the ones that spilled over to others, such as the net receivers in this period: Slovenia, Poland, and BiH. Interested investors obtain information from these findings, knowing not to include all of the receiving markets at the same time in his portfolio if he does not wish to have portfolio kurtosis lean to one side or the other. In other words, if he includes the net emitter markets in the portfolio, as well as the net receivers, shocks that could have occurred in this sub-period on emitters could have spilled to the receiver markets, and the resulting portfolio kurtosis would be overall affected more when compared to a case where he had diversified it. Moreover, some stock markets are closer to Ukraine than others in this study, and that is why the magnitude and sign of the spikes on Figures 2–5 differ, as this is in line with [94], who found that stock returns of Eastern Europe during the Russo-Ukrainian War in 2022 are affected by distance to Kyiv.

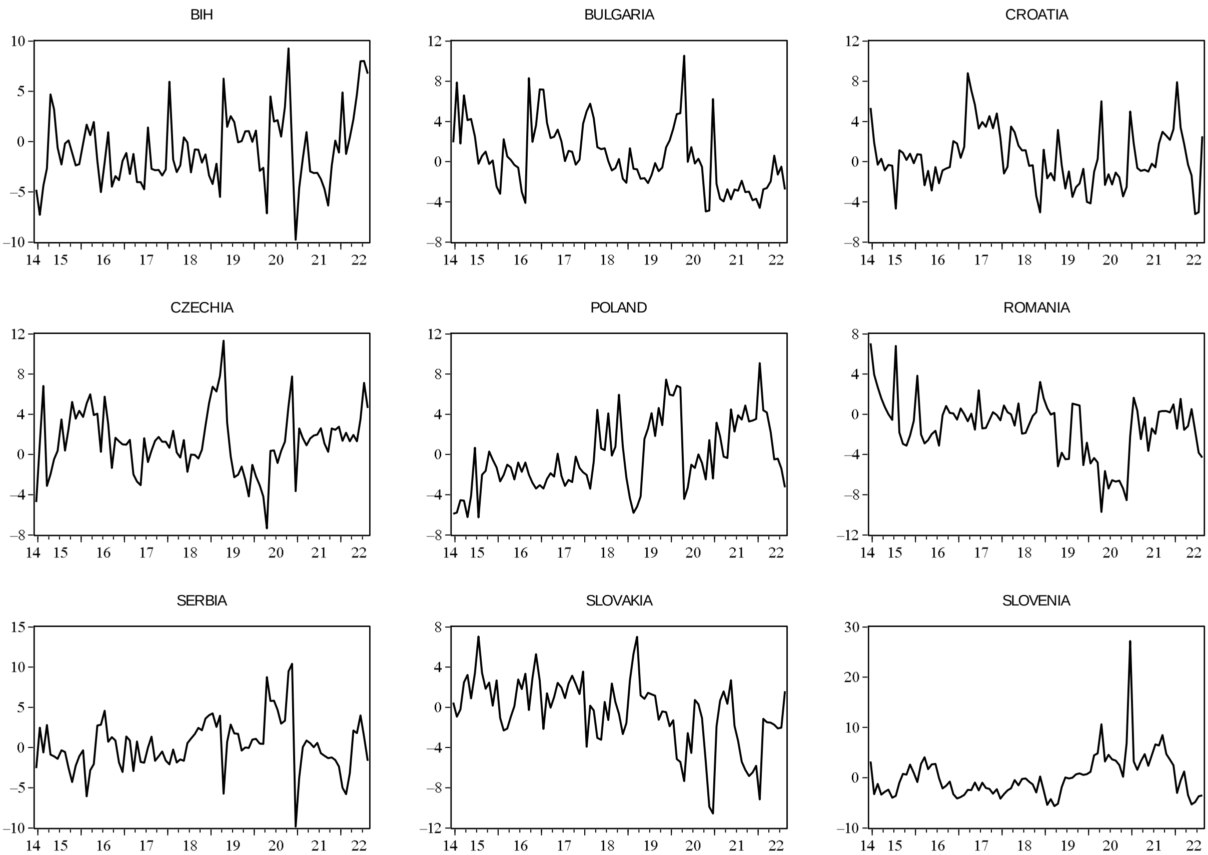


Figure 2. Net spillovers by country, 24-month rolling window length, return series. Source: author's calculation.

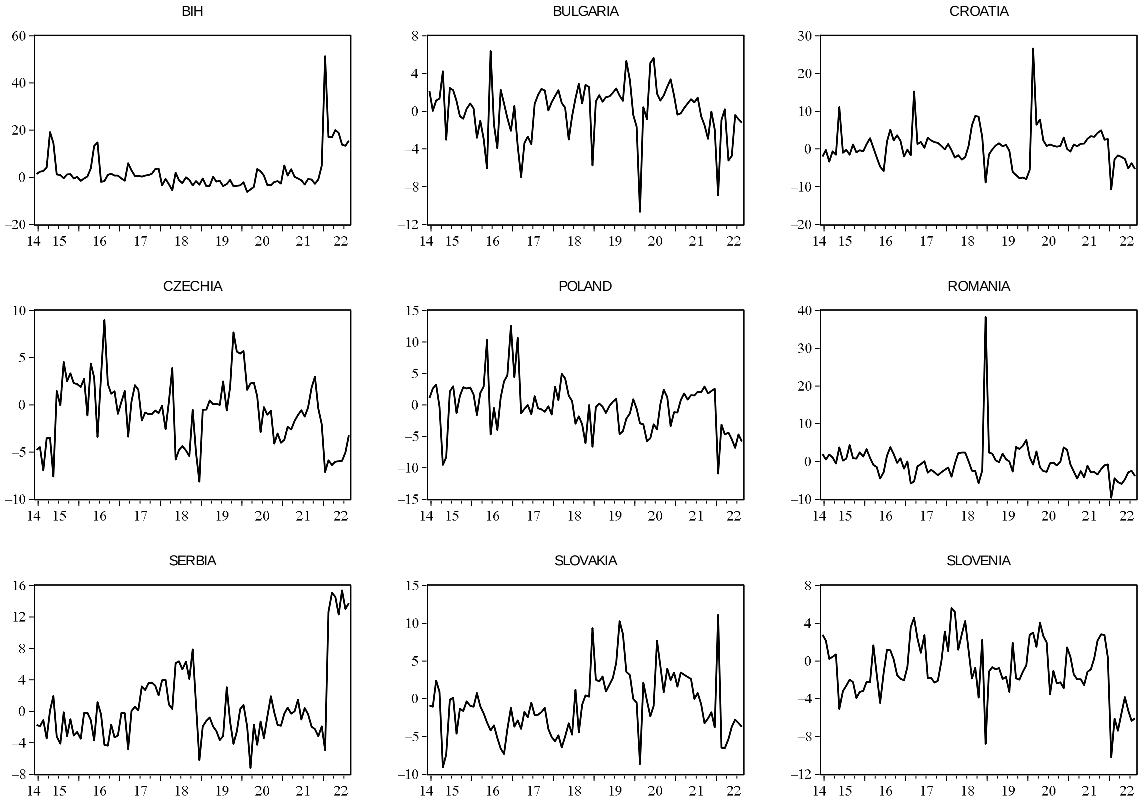


Figure 3. Net spillovers by country, 24-month rolling window length, standard deviation series. Source: author's calculation.

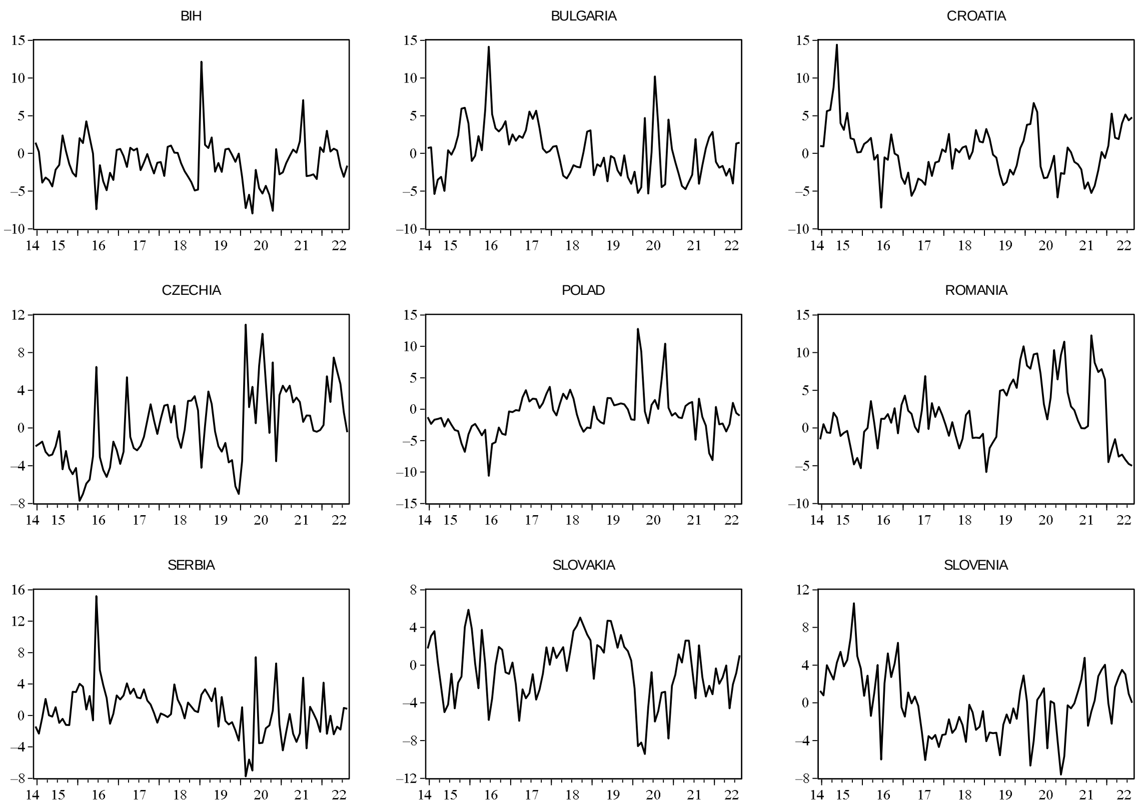


Figure 4. Net spillovers by country, 24-month rolling window length, skewness series. Source: author's calculation.

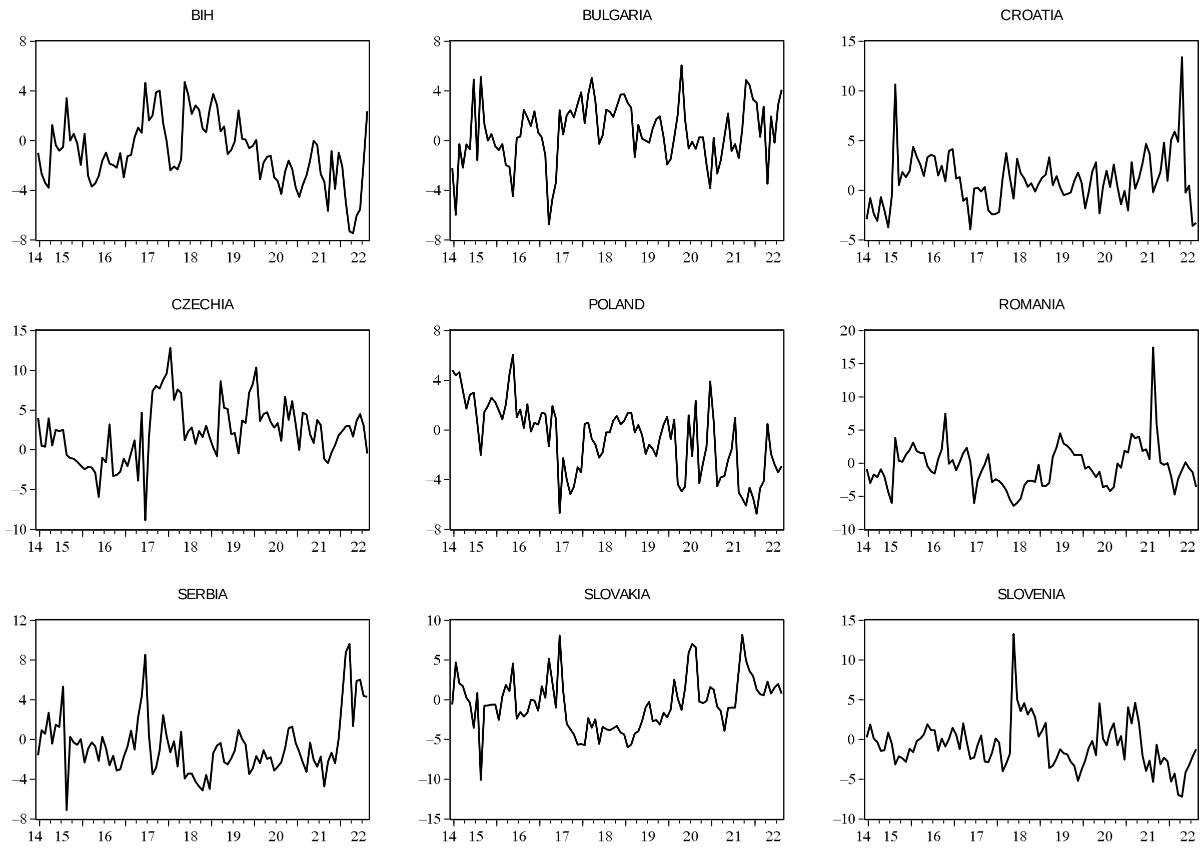


Figure 5. Net spillovers by country, 24-month rolling window length, kurtosis series. Source: author's calculation.

4.3. Robustness Checking

In order to test the robustness of the results, several approaches were made. Firstly, the length of the rolling window estimates was changed, as seen in the previous subsection. Second, a TVP-VAR (time varying parameter) model was estimated to contrast the results. And finally, quarterly frequencies were used to re-estimate the spillover table.

Net pairwise indices were estimated for every distribution moment and are shown in Figures A7–A10 for the case of 48 months rolling window length. The longest length is chosen so that general findings can be commented on, whereas the usual portfolio practice would observe such dynamics more frequently. Pairwise indices regarding return series in Figure A1 show that shocks such as the COVID-19 one have caused one market to become a net emitter of shocks to the other (e.g., in Slovakia and Slovenia's case), or vice versa. The war in Ukraine which started in the spring of 2022 has increased spillovers among some markets (e.g., Serbia and BiH), whereas they have decreased in other cases (BiH and Slovenia). The pairwise spillovers of risk series in Figure A2 show this. In contrast, there exist those countries that have good diversification possibilities when looking at their net index (e.g., those that have values around zero, such as Slovenia and Poland; or the decreasing spillover from Serbia to Czechia, as the net index converged towards zero value), others have increasing trends in spillovers (e.g., Romania and Slovakia) or periods when the spillovers stay for a longer time (Romania and Poland). If one looks at the pairwise skewness spillovers in Figure A3, asymmetry of one market was affecting the other's market in some cases (e.g., Serbia and Bulgaria). Other cases are found to have deteriorating values for the individual spillovers (e.g., Slovenia and Bulgaria), which means that the last couple of years experienced changes of individual asymmetry without the effects coming from other markets. Finally, Figure A4 shows the extent of the pairwise spillover between the kurtosis series. Similar things could be said for the previously discussed examples. The fatness of the tails of individual return distributions exhibit different dynamics throughout the sample, with some markets affecting the kurtosis, i.e., the probabilities of extreme events in the other market. Some shifted from being the emitter to the receiver of shocks, or the other way around, and one can draw different general conclusions, such as specific shocks shifting the conclusion about being emitter or receiver, etc.

Another robustness check was the re-estimation of the spillover tables for the case of TVP-VAR (time varying parameter) model case, as some approaches utilize this framework, instead of the rolling window approach. All of the models have been re-estimated with the TVP approach, and the total spillover table, as in the case of Tables 1–4, was calculated. The new tables are shown in Appendix A, Figures A17–A20. It can be seen that the differences are minor, with the exception of some spillover values for the standard deviation cases of some countries. However, the net givers and receivers of shock remain the same.

Finally, additional robustness testing was done on quarterly data. The same analysis was redone for all four moments but in the case of average quarterly returns, quarterly standard deviation, skewness, and kurtosis. The dynamics of higher moments on a monthly basis are shown in Figures A5 and A6, whereas Figures A7 and A8 depict their quarterly counterparts. It can be seen that the dynamics are similar, i.e., the stability of the monthly series is rather good. Moreover, the spillover tables for all four moments are compared in Figures A13–A15, where the results are very much alike. Some differences exist, as shown by the fact that although VAR models for the case of quarterly data were estimated with one lag, as with the models for the monthly data here, one lag meaning that three months are included in that one-quarter lag. Thus, the resulting spillovers accumulate more, and the values of some spillover indices are more significant for the quarterly data case.

4.4. Discussion

To summarize the findings, it could be said that overall, the least receiving markets were BiH (first three moments), Bulgaria and Slovakia (first, second, and the fourth moment), Serbia and Romania (second moment), and Czechia (third moment). Markets that emitted the greatest number of shocks to others were Croatia (all moments), Czechia and Slovenia (first two moments), Romania (third moment), and Serbia (fourth moment). The greatest receivers of shocks from others were Poland (all moments), Croatia (second, third and fourth), Slovenia (first two), Czechia (first), Bulgaria (third), and BiH (fourth). These results align with [95], where Slovakian and BiH markets were found to have evidence of segmentation, which is beneficial for diversification purposes. Moreover, [50] analyzed the effects of general shocks in CEE and SEE regional market indices on individual markets and found that the two mentioned markets received the least amount of such shocks. An earlier study by [96] found a similar conclusion for the Slovakian market and the Eurozone. Thus, this market provides beneficial opportunities to include it in the international portfolio. Czech and Polish markets as receivers of shocks are in line with [97] and [98]. Slovakia and BiH were found to be the most closed markets in terms of receiving shocks from others in [1,20,39,90,99] as well. Some of the possible reasons why such results are obtained are as follows. In [4] determinants of spillovers between 40 countries were examined. The author found that the greater the bilateral equity or debt security exposures between countries, the more the spillovers between the countries. A similar observation is found in [100], who find that bilateral trade intensity is a factor affecting the value of shock spillovers between markets. Moreover, [4] found that some of the main determinants of financial spillovers between countries are the bilateral asset holdings and countries' geographical preferences. This is corroborated by the [101] Report, which suggests that bank exposures, FDI (foreign direct investment), and portfolio investment are some of the main drivers of spillovers between markets. This could be why spillovers are more significant among some countries and much less significant for others. [25] found that the size, development, and concentration of CESEE markets are some of the main differences that affect their dynamics. The authors found that the Polish market was the most developed regarding market size, concentration indices, and liquidity, whereas the Serbian and Slovakian markets were the least developed. This could also be a reason for why the Polish market has the greatest spillovers in the analysis given in this paper, and the other two mentioned markets had much less connectedness to others in the study. Other explanations are herding effects, as described in behavioral studies by [102], who focused on CEE countries. Investor sentiment has been examined for quite some time, and some findings include that cultural independence and interdependence can affect investor sentiment (see [103]), alongside herding behavior affecting market expectations (as found in [104,105], or [106]). Finally, some differences could be found in institutional trust across countries, which also affect investor actions, as seen in [107].

Finally, some shocks stay longer in the system, whereas others dissipate quickly. Some explanations for this might be found in interdependence and contagion literature. First, not all shocks are considered to be negative. Contagion is defined and observed when shocks on one market spill to others, and adverse effects are in play ([108]. After such shocks, the connectedness between markets rises and stays higher for longer [8]. Stable periods characterized by high connectedness between some markets are defined as interdependence, as found in [8]. This means that due to higher linkages between some markets due to trade, geographical distance, or other criteria, the co-movements between those markets are pretty high and are not a result of some specific shock. Future research could focus on investigating the spillovers of this study in terms of finding evidence of interdependence or contagion. Based on this discussion, it can be concluded that both hypotheses are confirmed: the first one regarding existence of significant spillovers between CESEE markets' higher moments, as the results indicate fairly high values of spillovers between some countries. The second hypothesis was that these spillover values change over time, and this was also confirmed, as the dynamic part of the research also showed that the values of spillover indices have a wide range of values.

5. Conclusions

The main findings of this research point out that although the CESEE markets are connected when observing all four moments of their distributions, there still exist periods and markets that show no sign of shock spillovers, at least in some short runs. This is important for dynamic portfolio rebalancing over time. Interested investors could use the results from this study to form portfolios based on the dynamics of the net and pairwise indices, depending on their preferences. Those that focus on minimizing the risk could concentrate on the risk spillovers over time. Others that instead look at reducing the kurtosis, i.e., the probabilities of extreme events, could investigate results regarding kurtosis in more detail. Of course, those who want to consider all moments at once would have a difficult task, as many more things then need to be considered.

The connectedness of stock markets has been extensively examined over the last decade. However, most research focuses on return and risk series in the usual MGARCH or VAR framework. There still exist gaps in the literature regarding the higher moments, specific markets such as CESEE ones, and investment possibilities of exploiting results that stem from such analysis. Although significant spillovers exist between some markets and moments, there still exist opportunities for dynamic portfolio rebalancing over time. This is important for portfolio managers, as they should consider not only the movements in the first two moments of return distributions of CESEE markets but also the higher ones. Future work should investigate the possible sources of specific dynamics between each pair of market distribution moments, as found in this research. This could help potential investors determine the most significant sources of connectedness between CESEE markets for all moments besides the usual variables examined in the literature. Moreover, other methodological approaches could be further used to examine specific spillovers and interconnectedness, such as the EEMD transfer entropy analysis (ensemble empirical mode decomposition) as in [109], quantile-on-quantile regressions [110], wavelet coherence analysis (as in [111]), etc.

Finally, this study had some shortcomings. First, due to data unavailability, a relatively short period was observed to look at dynamics over time. Other crises and specific economic events could be beneficial to study, as they would provide insights if the nature of spillover depending on the news and shocks that occur. Next, daily and weekly data were not utilized, as the control variables were unavailable at those frequencies. If a fund manager or insurer deals with models that utilize daily or another type of frequency data, this research approach could also be made on different data. Here, as our general conclusions are observed, the monthly frequency was sufficient to comment if some specific findings could be observed. Of course, those that rebalance their portfolio, especially funds or insurers, would complement this approach with existing ones which are already good at achieving specific goals.

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Conflicts of Interest: The author declares no conflict of interest.

Appendix A

Table A1. Daily stock market indices descriptive statistics.

Stat/Country	BiH	Bulgaria	Croatia	Czechia	Poland	Romania	Serbia	Slovakia	Slovenia
Mean	643.9314	541.5598	1838.456	1036.798	2453.606	8326.091	691.8562	305.1225	839.4028
Median	616.7700	550.9700	1828.510	1017.670	2521.930	7953.880	711.1900	326.4650	809.5400
Maximum	853.5000	730.9000	2246.340	1481.680	3017.460	13,681.92	865.0600	405.5500	1338.140
Minimum	488.0000	360.3800	1364.980	690.3700	1521.190	5223.360	476.0300	178.6500	579.5600
Standard Deviation	83.78498	84.97829	140.8109	131.3887	277.1176	2032.892	87.53849	62.72771	162.7738
Skewness	0.350548	0.069994	0.150992	1.093392	−0.600925	0.877353	−0.315858	−0.662225	1.022758
Kurtosis	1.900718	2.024832	3.073858	4.281231	2.626802	2.914902	2.434104	2.190514	3.473096
Observations	2381	2303	2314	2350	2331	2349	2379	2320	2346

Source: author's calculation.

Table A2. Daily return series descriptive statistics.

Stat/Country	BiH	Bulgaria	Croatia	Czechia	Poland	Romania	Serbia	Slovakia	Slovenia
Mean	3.71×10^{-5}	0.000320	7.43×10^{-5}	7.96×10^{-5}	-7.67×10^{-5}	0.000368	0.000279	0.000247	0.000222
Median	0.000000	0.000195	0.000260	0.000450	−0.00013	0.000548	0.000155	0.000000	0.000296
Maximum	0.099106	0.058003	0.057840	0.076475	0.084206	0.070546	0.041721	0.095464	0.061401
Minimum	−0.10613	−0.10247	−0.10176	−0.07836	−0.1309	−0.11212	−0.05996	−0.08907	−0.08956
Standard Deviation	0.008847	0.008146	0.007061	0.009587	0.012587	0.009673	0.006723	0.010444	0.008696
Skewness	0.466717	−1.28244	−2.96748	−0.76533	−0.71829	−1.38383	−0.47006	0.159725	−1.14938
Kurtosis	33.10807	23.31062	47.07194	11.80693	13.07985	23.08725	10.36338	13.47783	15.41520

Source: author's calculation.

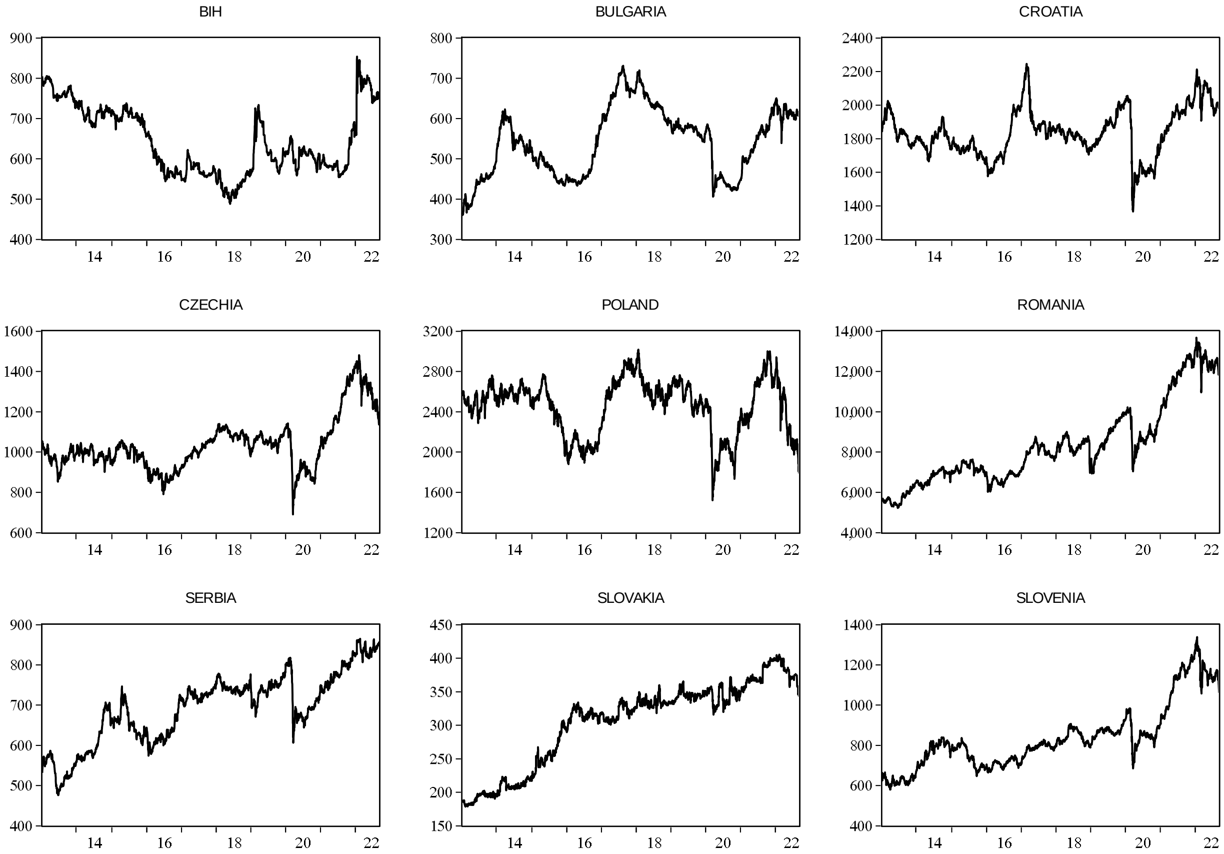

Figure A1. Daily stock market indices. Source: author's calculation.

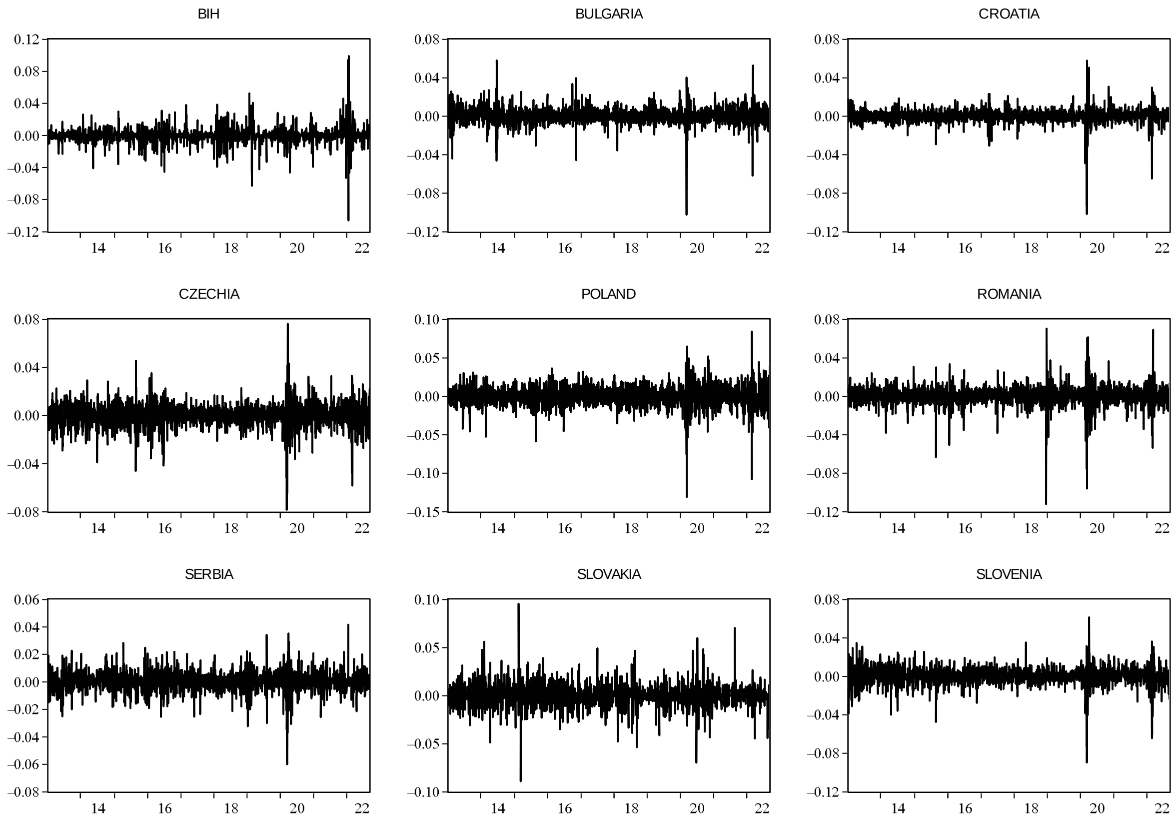

Figure A2. Daily stock market returns. Source: author's calculation.

Table A3. Descriptive statistics for monthly return series.

Stat/Country	BiH	Bulgaria	Croatia	Czechia	Poland	Romania	Serbia	Slovakia	Slovenia
Mean	7.13×10^{-5}	0.000360	8.32×10^{-5}	0.000106	-6.97×10^{-5}	0.000345	0.000279	0.000258	0.000177
Median	-7.15×10^{-5}	5.65×10^{-5}	0.000324	0.000129	-5.30×10^{-6}	0.000519	0.000394	0.000247	0.000257
Maximum	0.016418	0.006725	0.004368	0.006678	0.010743	0.005060	0.004651	0.006578	0.005415
Minimum	−0.003552	−0.012626	−0.009633	−0.008905	−0.007461	−0.009279	−0.010066	−0.004285	−0.010344
Standard Deviation	0.002304	0.002209	0.001726	0.002066	0.002645	0.002207	0.001703	0.001853	0.002388
Skewness	3.275513	−1.195353	−1.681821	−0.509492	0.156199	−1.238039	−2.118121	0.373654	−1.464964
Kurtosis	23.36702	12.46476	10.94985	5.992223	4.949197	6.518762	14.14489	4.219721	8.154166

Source: author's calculation.

Table A4. Descriptive statistics for monthly variances.

Stat/Country	BiH	Bulgaria	Croatia	Czechia	Poland	Romania	Serbia	Slovakia	Slovenia
Mean	0.007241	0.007094	0.005616	0.008476	0.011425	0.008236	0.006103	0.009690	0.007595
Median	0.006004	0.006517	0.004587	0.007520	0.010167	0.006793	0.005433	0.009266	0.006679
Maximum	0.049279	0.033230	0.039415	0.038545	0.045871	0.039140	0.021194	0.023157	0.032311
Minimum	0.001624	0.002557	0.002223	0.003775	0.004035	0.003344	0.002075	0.002963	0.002696
Standard Deviation	0.005443	0.003842	0.004043	0.004428	0.005563	0.005208	0.002696	0.004056	0.004145
Skewness	4.298188	3.657880	5.582481	3.205208	3.079949	3.490675	2.147520	0.862173	3.010675
Kurtosis	31.93534	21.99114	43.94696	20.02660	17.13820	18.38000	11.02063	3.732704	15.35399

Source: author's calculation.

Table A5. Descriptive statistics for monthly skewness series.

Stat/Country	BiH	Bulgaria	Croatia	Czechia	Poland	Romania	Serbia	Slovakia	Slovenia
Mean	−0.27927	0.116807	−0.041939	−0.134078	0.032499	−0.131671	0.040117	−0.036594	−0.03375
Median	−0.286481	0.200102	−0.032636	−0.141265	0.040694	−0.096479	0.116690	0.089706	0.012149
Maximum	2.752586	1.877989	1.673172	2.319821	1.225006	1.666010	3.476776	3.375069	1.941871
Minimum	−4.044956	−1.827843	−2.468369	−1.248075	−1.916821	−2.100809	−2.105861	−2.913228	−1.752573
Standard Deviation	1.322092	0.754118	0.723442	0.585202	0.546781	0.752774	0.812399	1.119690	0.727940
Skewness	−0.007247	−0.446333	−0.513942	0.874980	−0.343987	−0.284121	0.245956	−0.19051	0.035927
Kurtosis	3.083324	3.108743	4.268296	4.822681	3.641341	3.318902	5.119627	4.540815	3.165301

Source: author's calculation.

Table A6. Descriptive statistics for monthly kurtosis series.

Stat/Country	BiH	Bulgaria	Croatia	Czechia	Poland	Romania	Serbia	Slovakia	Slovenia
Mean	5.560823	3.523394	3.281847	3.168800	3.003347	3.402027	3.819662	4.798262	3.463136
Median	5.190977	3.141786	2.895778	2.936180	2.844547	2.885297	3.338897	3.965334	3.080390
Maximum	18.25734	8.543468	10.23164	9.836766	7.560064	9.157626	13.77045	14.74627	8.848761
Minimum	1.867525	1.500000	1.561404	1.596096	1.519699	1.639264	1.626842	1.500000	1.672573
Standard Deviation	2.734199	1.422442	1.509396	1.181424	1.025784	1.514156	1.785327	2.598195	1.327632
Skewness	1.546823	1.382343	2.150178	2.125569	1.603559	1.629293	2.280596	1.969594	1.524391
Kurtosis	6.811169	4.894461	8.679120	10.89899	6.590134	5.318545	10.82985	6.501978	5.709315

Source: author's calculation.

Table A7. Correlation matrix for monthly return series, full sample.

	BiH	Bulgaria	Croatia	Czechia	Poland	Romania	Serbia	Slovakia	Slovenia
BiH	1.000	0.043	0.147	0.059	−0.006	0.108	0.250	0.114	0.154
Bulgaria	0.043	1.000	0.410	0.291	0.273	0.229	0.442	0.109	0.414
Croatia	0.147	0.410	1.000	0.458	0.411	0.497	0.532	0.037	0.521
Czechia	0.059	0.291	0.458	1.000	0.634	0.492	0.451	0.079	0.484
Poland	−0.006	0.273	0.411	0.634	1.000	0.361	0.253	0.096	0.456
Romania	0.108	0.229	0.497	0.492	0.361	1.000	0.362	0.052	0.448
Serbia	0.250	0.442	0.532	0.451	0.253	0.362	1.000	0.074	0.403
Slovakia	0.114	0.109	0.037	0.079	0.096	0.052	0.074	1.000	0.121
Slovenia	0.154	0.414	0.521	0.484	0.456	0.448	0.403	0.121	1.000

Source: author's calculation.

Table A8. Correlation matrix for monthly variances, full sample.

	BiH	Bulgaria	Croatia	Czechia	Poland	Romania	Serbia	Slovakia	Slovenia
BiH	1.000	0.094	0.193	0.071	0.208	0.229	0.184	−0.103	0.143
Bulgaria	0.094	1.000	0.624	0.553	0.422	0.506	0.408	−0.003	0.693
Croatia	0.193	0.624	1.000	0.691	0.700	0.608	0.483	−0.024	0.735
Czechia	0.071	0.553	0.691	1.000	0.788	0.685	0.520	0.118	0.702
Poland	0.208	0.422	0.700	0.788	1.000	0.655	0.452	−0.019	0.632
Romania	0.229	0.506	0.608	0.685	0.655	1.000	0.540	−0.031	0.585
Serbia	0.184	0.408	0.483	0.520	0.452	0.540	1.000	−0.126	0.450
Slovakia	−0.103	−0.003	−0.024	0.118	−0.019	−0.031	−0.126	1.000	0.060
Slovenia	0.143	0.693	0.735	0.702	0.632	0.585	0.450	0.060	1.000

Source: author's calculation.

Table A9. Correlation matrix for monthly skewness series, full sample.

	BiH	Bulgaria	Croatia	Czechia	Poland	Romania	Serbia	Slovakia	Slovenia
BiH	1.000	0.085	0.023	0.163	0.035	0.024	−0.032	0.045	−0.007
Bulgaria	0.085	1.000	0.152	0.004	0.204	0.203	0.072	0.105	0.222
Croatia	0.023	0.152	1.000	0.193	0.302	0.220	−0.071	−0.007	0.226
Czechia	0.163	0.004	0.193	1.000	0.143	0.025	0.114	−0.013	0.058
Poland	0.035	0.204	0.302	0.143	1.000	0.223	0.085	−0.015	0.137
Romania	0.024	0.203	0.220	0.025	0.223	1.000	0.021	−0.218	0.163
Serbia	−0.032	0.072	−0.071	0.114	0.085	0.021	1.000	−0.023	−0.078
Slovakia	0.045	0.105	−0.007	−0.013	−0.015	−0.218	−0.023	1.000	−0.050
Slovenia	−0.007	0.222	0.226	0.058	0.137	0.163	−0.078	−0.050	1.000

Source: author's calculation.

Table A10. Correlation matrix for monthly kurtosis series, full sample.

	BiH	Bulgaria	Croatia	Czechia	Poland	Romania	Serbia	Slovakia	Slovenia
BiH	1.000	0.138	0.144	0.215	0.140	0.196	0.159	−0.028	0.032
Bulgaria	0.138	1.000	0.104	0.185	0.133	0.088	0.046	0.156	−0.015
Croatia	0.144	0.104	1.000	0.156	0.360	0.252	0.061	−0.089	0.208
Czechia	0.215	0.185	0.156	1.000	0.246	0.110	0.128	0.070	0.022
Poland	0.140	0.133	0.360	0.246	1.000	0.140	0.018	−0.042	−0.052
Romania	0.196	0.088	0.252	0.110	0.140	1.000	0.053	0.126	0.069
Serbia	0.159	0.046	0.061	0.128	0.018	0.053	1.000	0.074	−0.148
Slovakia	−0.028	0.156	−0.089	0.070	−0.042	0.126	0.074	1.000	−0.114
Slovenia	0.032	−0.015	0.208	0.022	−0.052	0.069	−0.148	−0.114	1.000

Source: author's calculation.

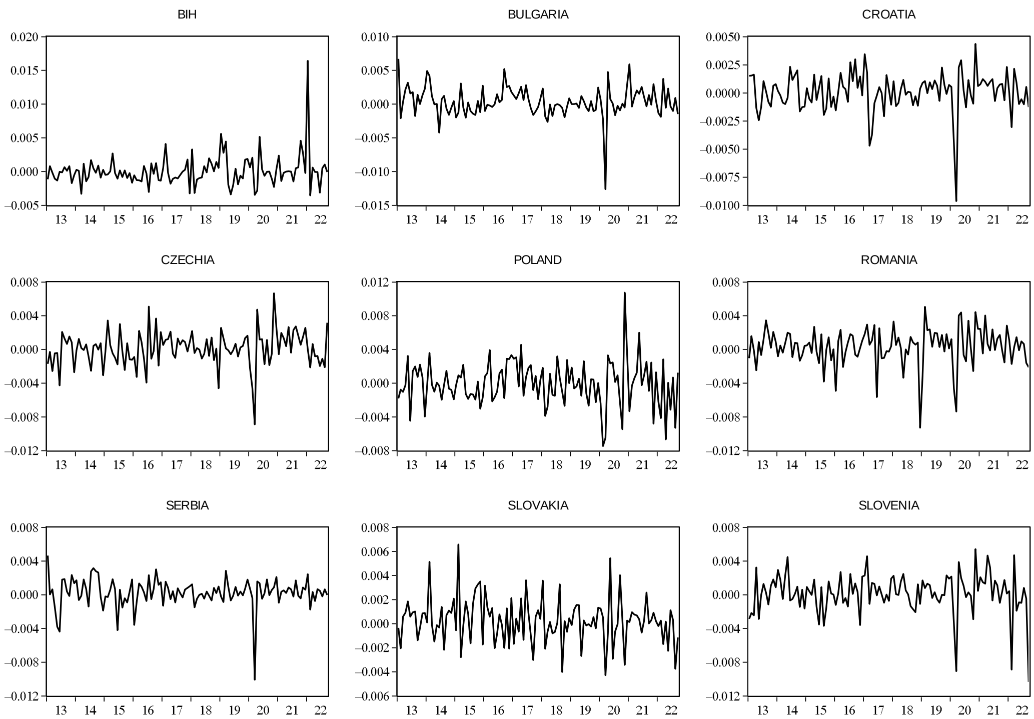

Figure A3. Monthly stock market returns. Source: author's calculation.

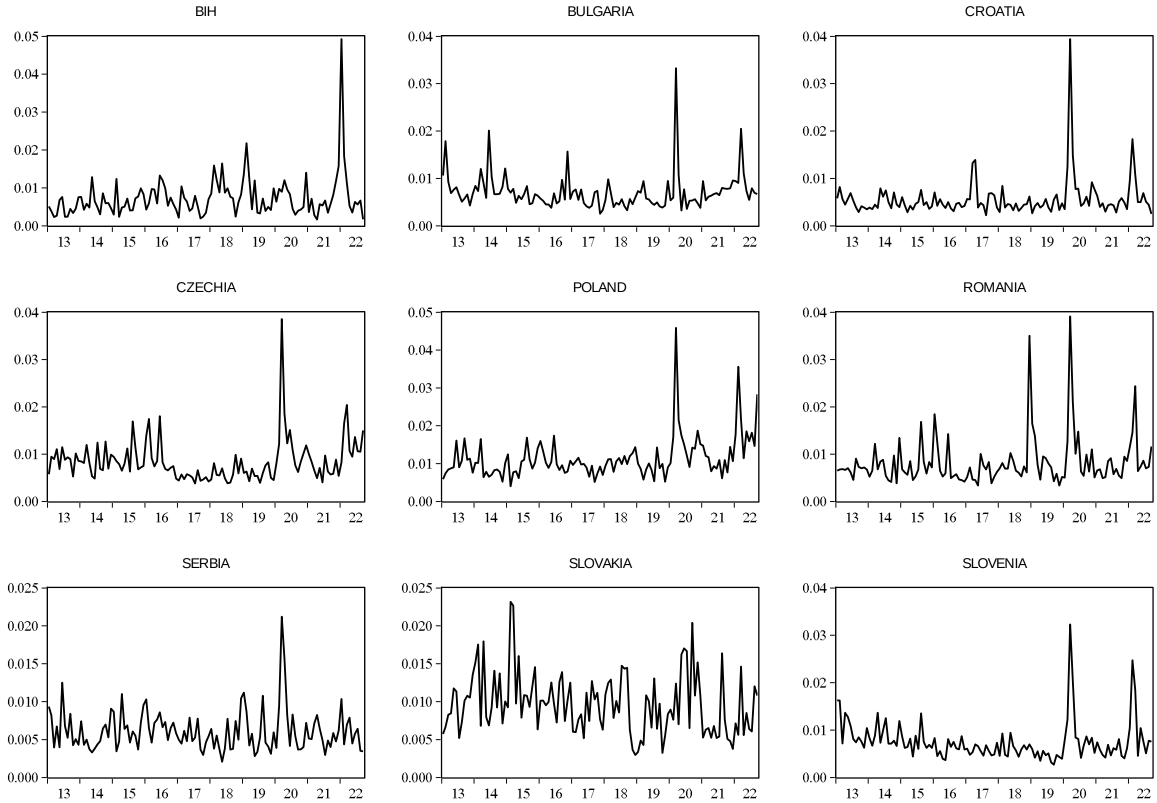

Figure A4. Monthly standard deviations. Source: author's calculation.

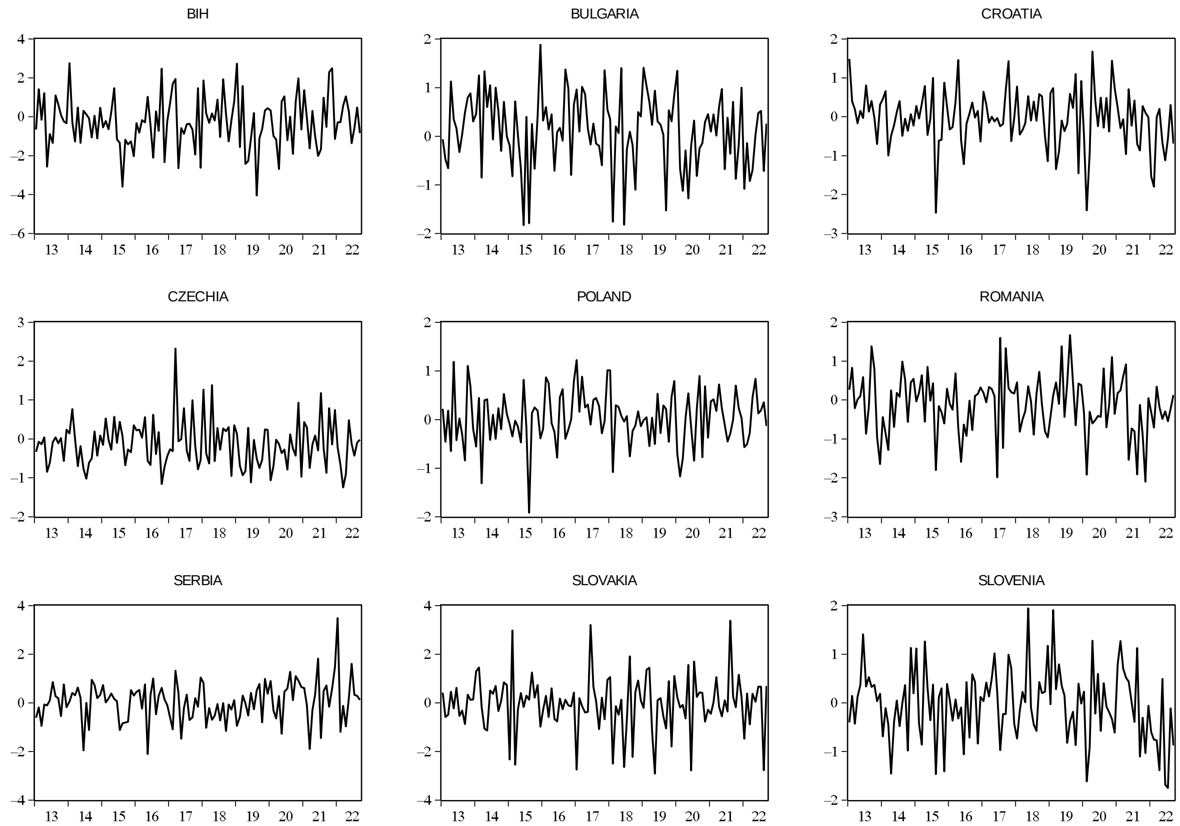

Figure A5. Monthly skewness. Source: author's calculation.

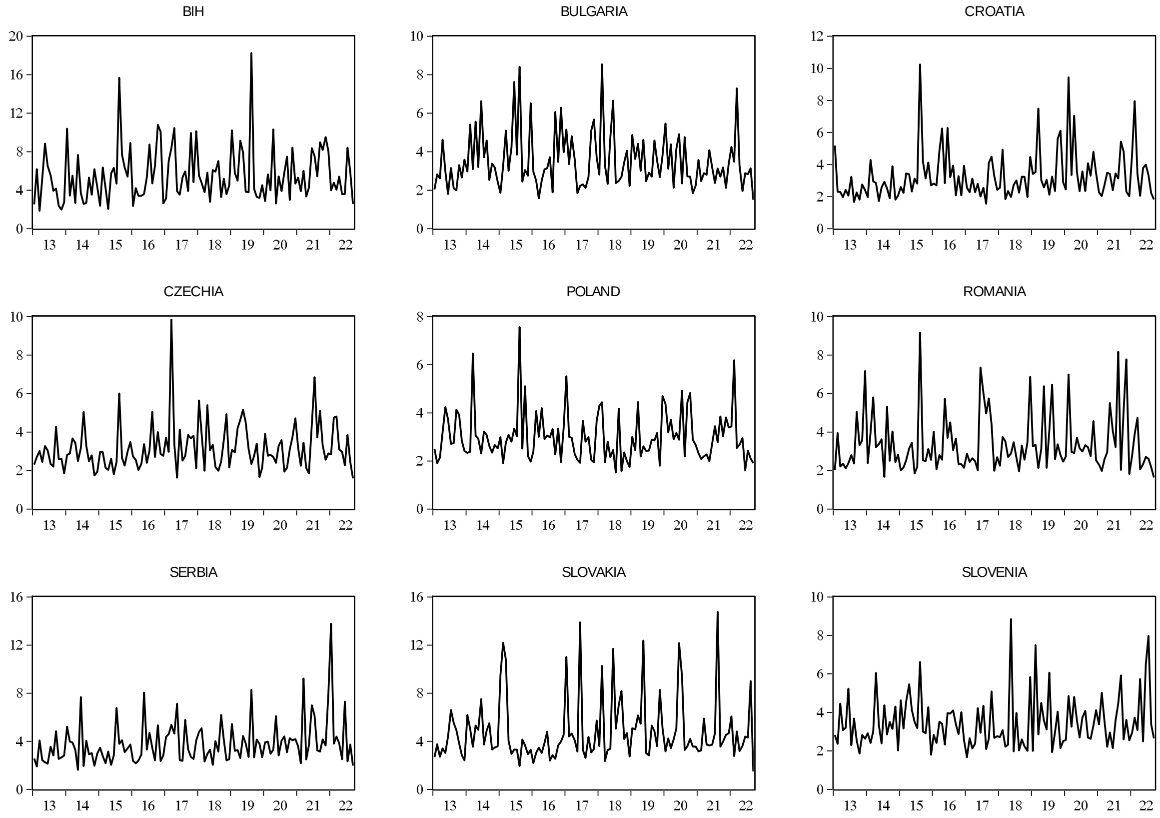

Figure A6. Monthly kurtosis. Source: author's calculation.

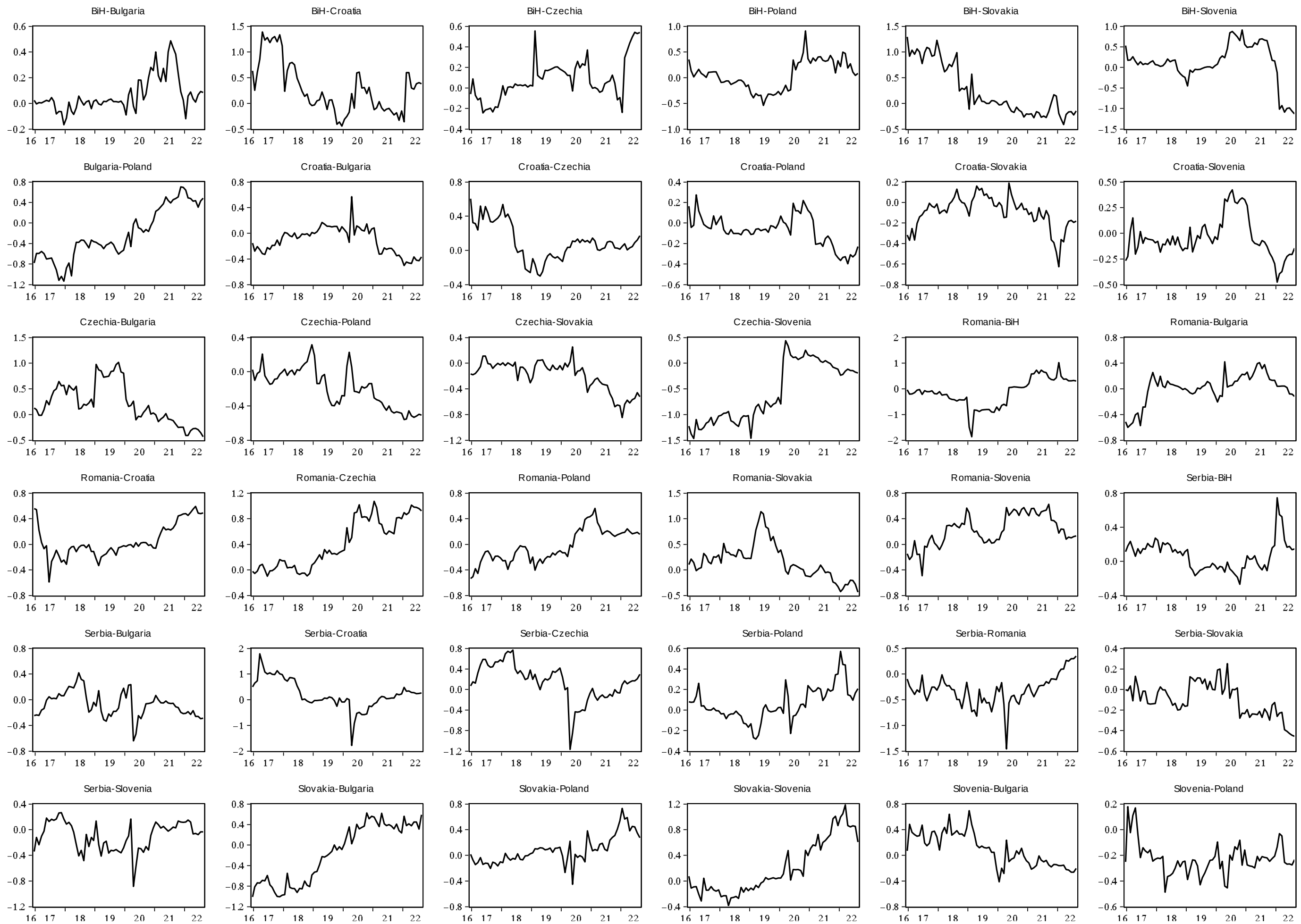

Figure A7. Pairwise spillover indices, mean return, 48-month length rolling window. Source: author's calculation.

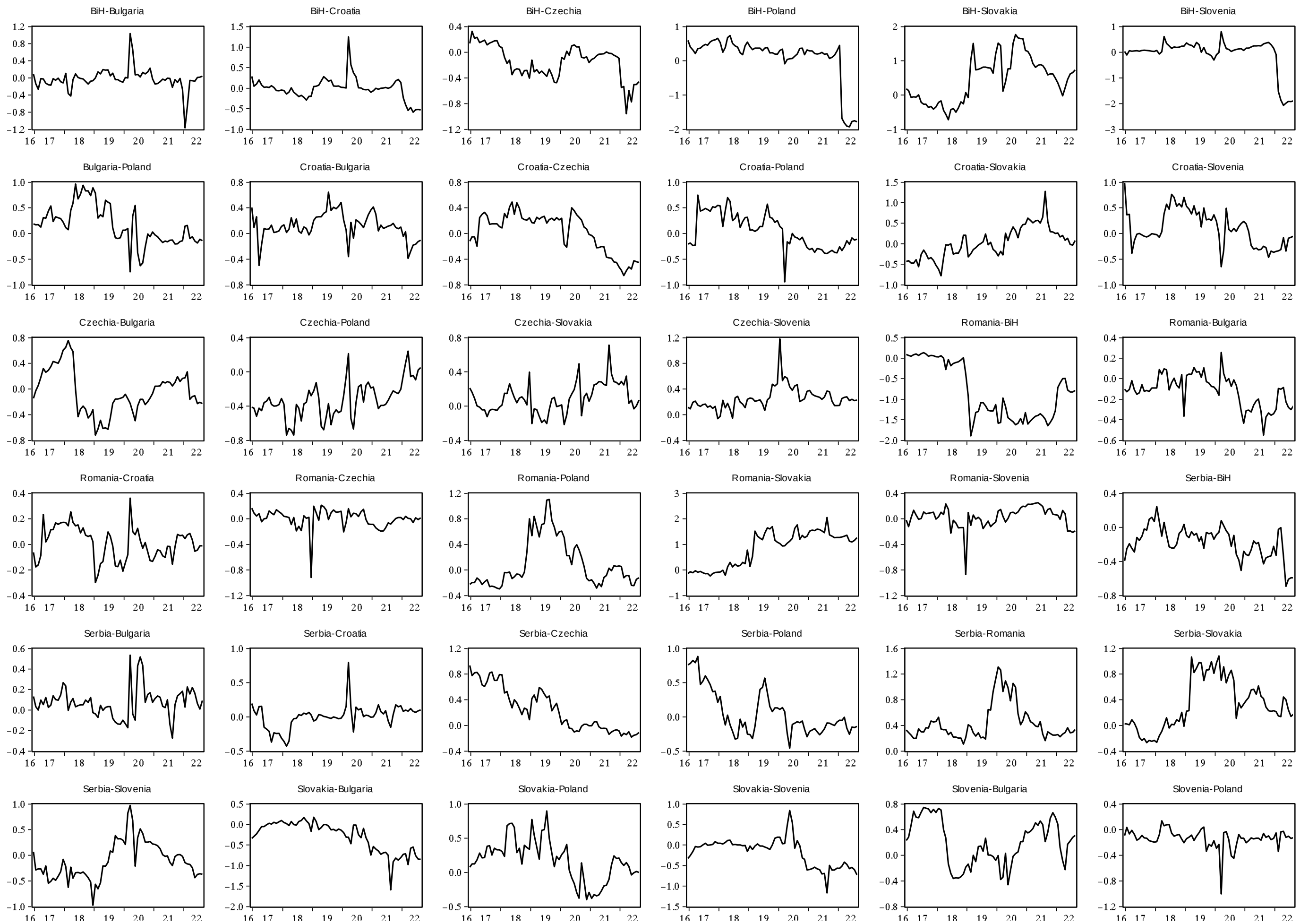

Figure A8. Pairwise spillover indices, standard deviation, 48-month length rolling window. Source: author's calculation.

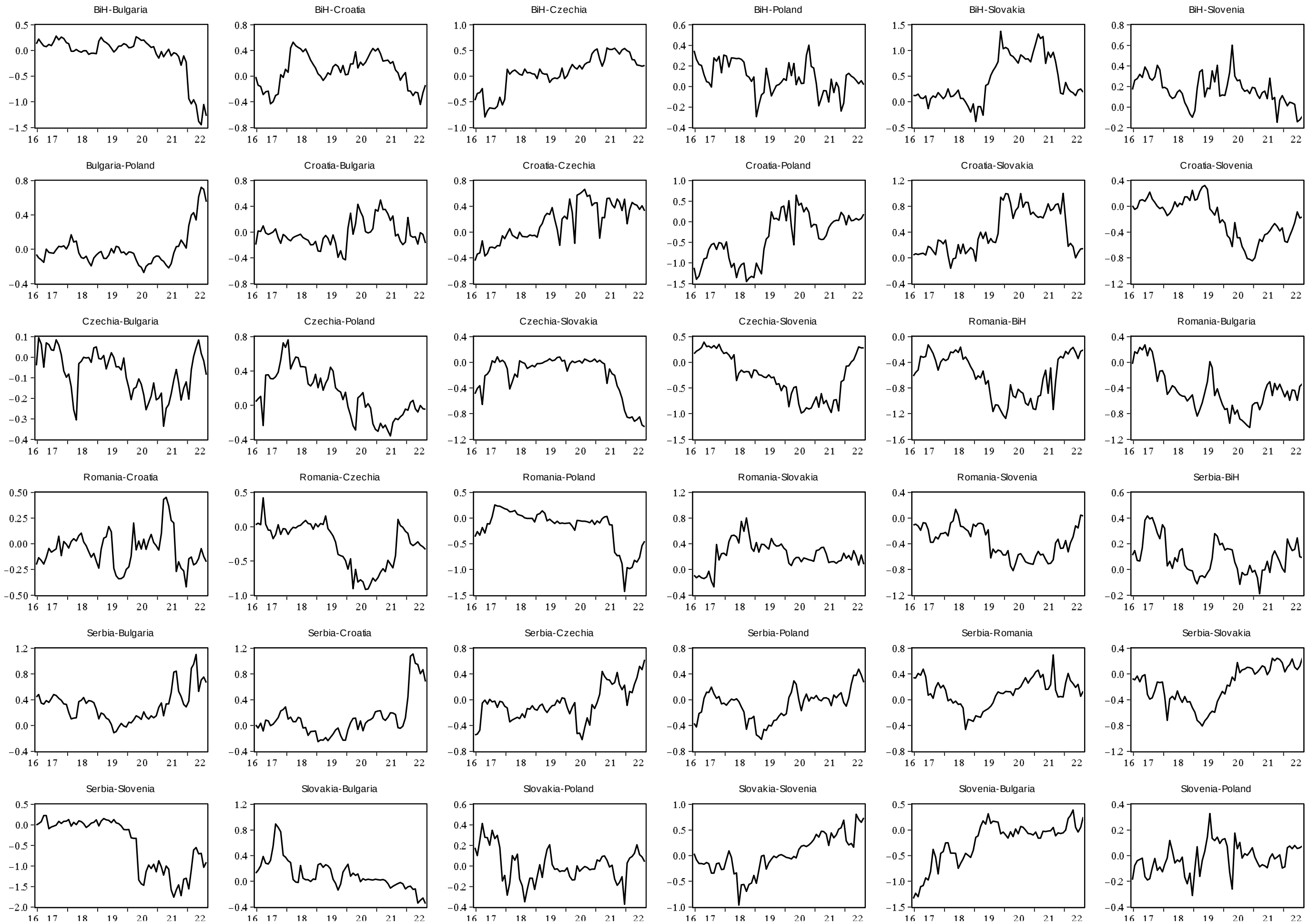

Figure A9. Pairwise spillover indices, skewness, 48-month length rolling window. Source: author's calculation.

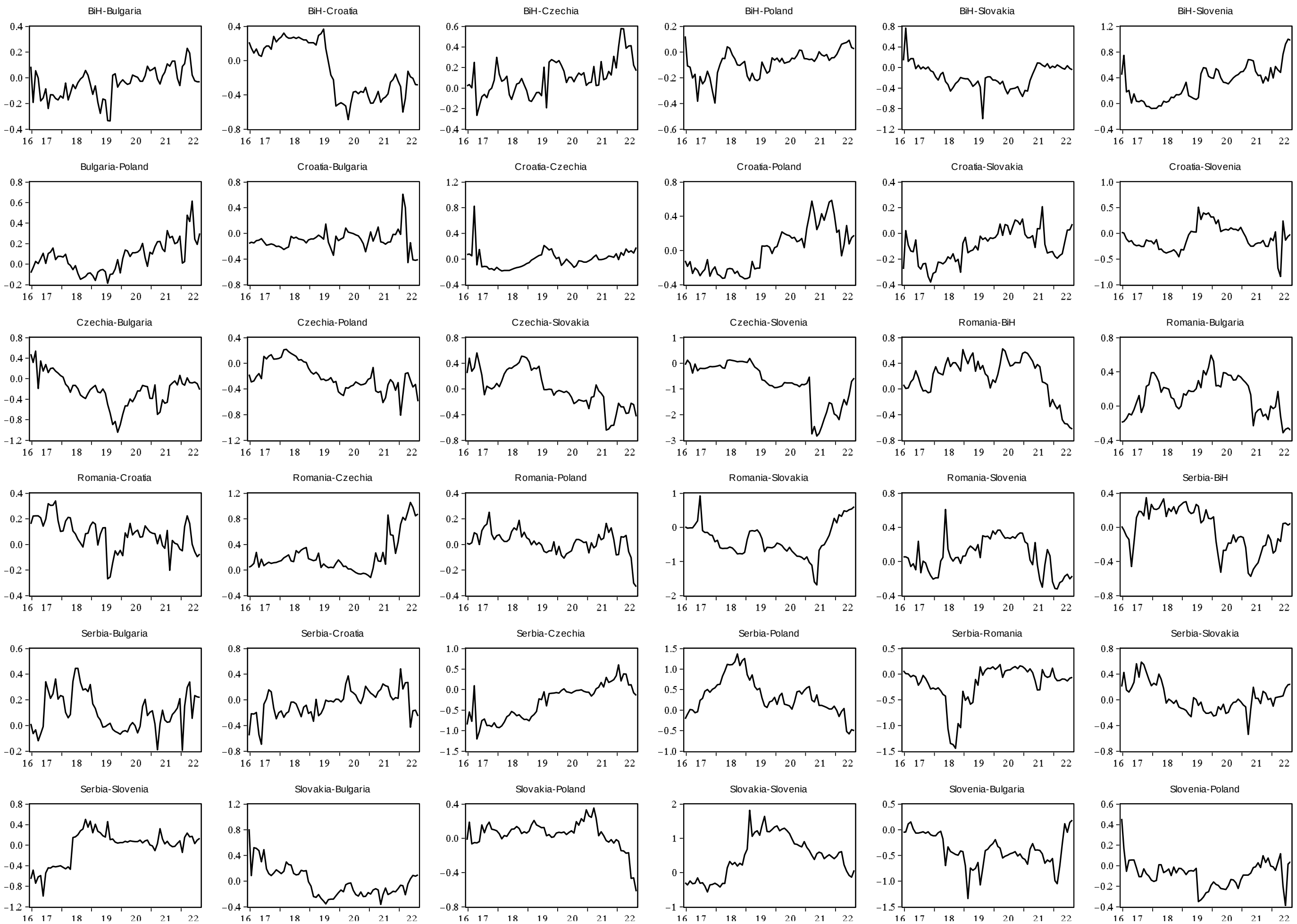

Figure A10. Pairwise spillover indices, kurtosis, 48-month length rolling window. Source: author's calculation.

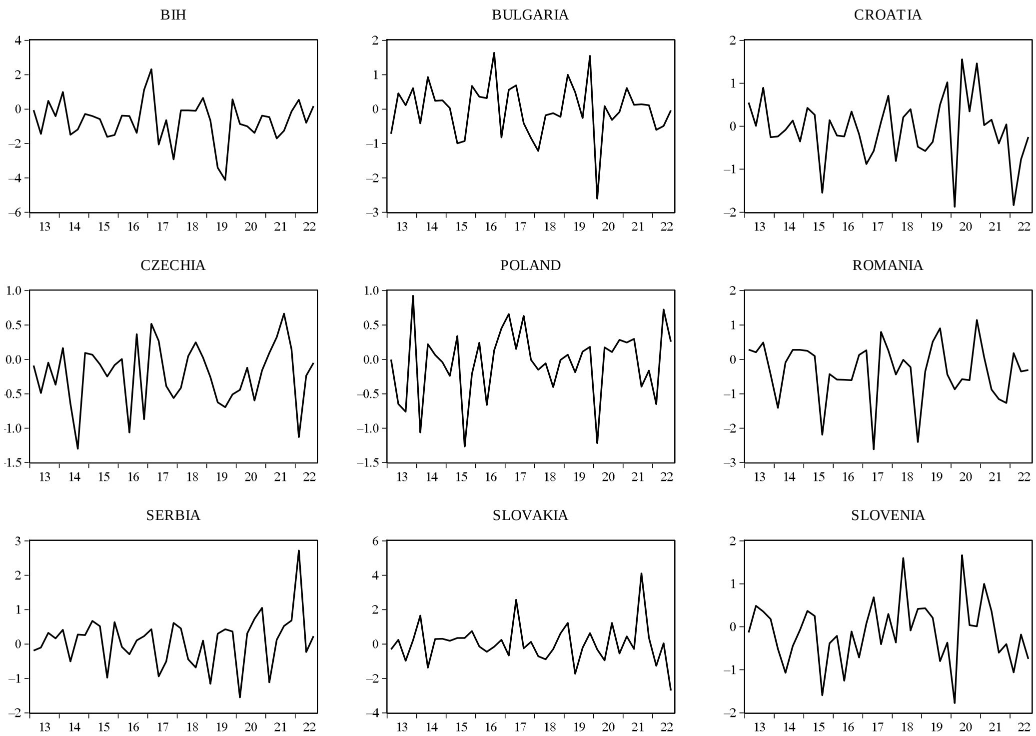

Figure A11. Quarterly series of skewness coefficients. Source: author's calculation.

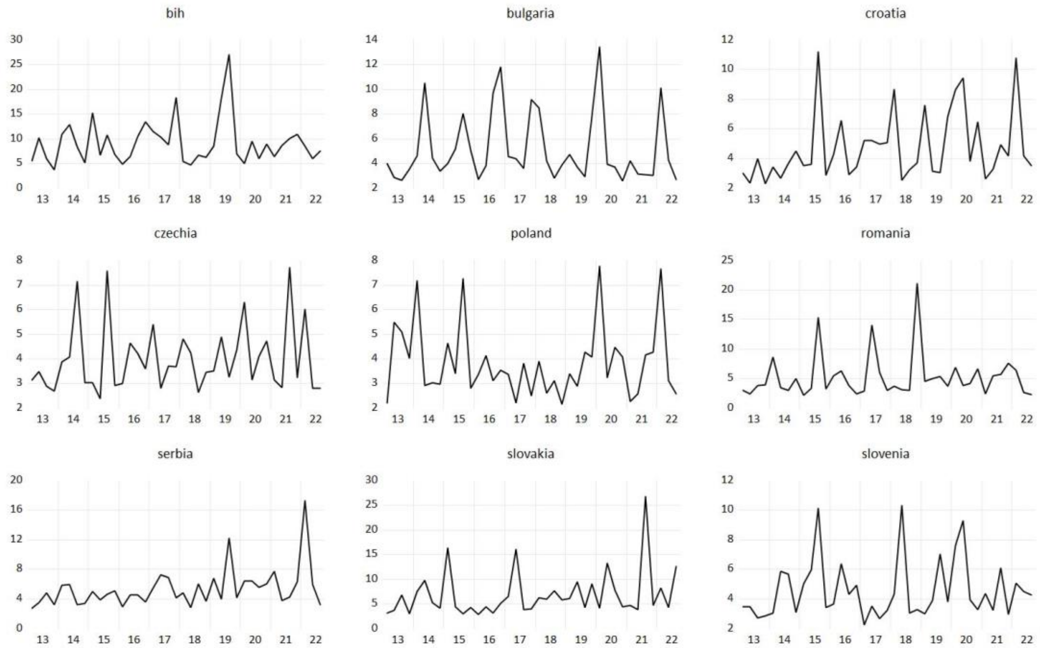

Figure A12. Quarterly series of kurtosis coefficients. Source: author's calculation.

Monthly	serbia	romania	bih	croatia	czechia	slovakia	slovenia	bulgaria	poland
serbia		6.66	1.93	11.53	10.22	0.89	10.06	5.96	4.31
romania	7.18		1.18	10.68	14.23	0.03	8.58	1.07	6.22
bih	2.46	0.55		8.71	4.46	1.19	2.02	0.34	2.82
croatia	9.78	9.26	3.19		8.74	0.22	11.51	4.79	6.98
czechia	9.45	10.01	0.33	7.6		0.47	13.02	3.3	16.07
slovakia	0.78	0.91	1.4	1.13	1.3		3.49	2.97	0.89
slovenia	9.98	6.4	5.78	10.58	12.7	0.31		6.09	9.8
bulgaria	8	1.27	0.91	6.91	5.05	1.19	9.83		6.8
poland	4.02	5.23	2.41	7.25	18.53	0.95	11.93	4.72	

Quarterly	serbia	romania	bih	croatia	czechia	slovakia	slovenia	bulgaria	poland
serbia		8.62	3.07	15.63	13.78	1.59	9.17	6.74	9.14
romania	10.04		0.62	17.85	15.19	0.43	15.09	5.16	6.9
bih	5.65	14.5		3.93	2.37	1.26	5.3	2.04	1.85
croatia	13.15	12.4	3.45		12.92	0.82	14.8	8.72	10.98
czechia	11.47	13.38	1.85	14.3		0.88	12.37	7.95	13.84
slovakia	1.43	0.4	0.53	0.46	1.94		1.66	11.31	4.78
slovenia	7.94	12.14	3.46	17.45	12.17	0.69		9.55	11.62
bulgaria	4.86	5.3	1.4	9.16	11.13	6.7	13.18		16.91
poland	8.98	6.99	2.12	11.39	17.34	1.74	10.58	13.72	

Figure A13. Comparison of spillover tables for monthly and quarterly data, return series. Source: author's calculation. Note: values on the main diagonal (spillovers within the same market) are deleted so that the intensity of spillovers between markets can be seen. Values start from 0 (dark green), and the higher the value is, the green color gets lighter to white and to light red, and finally dark red for the highest values in individual table.

Monthly	serbia	romania	bih	croatia	czechia	slovakia	slovenia	bulgaria	poland
serbia		8.55	1.9	4.19	4.07	5.8	4.38	3.28	6.97
romania	4.85		2	5.1	9.14	7.89	8.94	4.66	8.82
bih	2.57	5.66		0.51	1.39	2.68	0.49	0.32	0.46
croatia	2.08	4.6	4.15		9.48	3.56	12.93	8	12.07
czechia	3.02	7.5	0.87	9.09		0.81	15.88	6.55	11.6
slovakia	6.19	4.33	0.34	4.37	0.9		0.94	0.86	3.22
slovenia	2.08	6.43	5.33	12.96	11.69	1.68		12.59	9.01
bulgaria	2.11	5.12	2	11.01	7.02	2.45	16.57		0.92
poland	4.78	6.86	8.64	12.35	13.45	2.28	10.47	0.62	

Quarterly	serbia	romania	bih	croatia	czechia	slovakia	slovenia	bulgaria	poland
serbia		14.4	4.91	9.2	9.22	8.55	7.33	6.2	7.49
romania	11.54		2.59	8.35	16.04	3.44	11.46	9.07	10.12
bih	1	3.75		2.52	1.66	5.37	16.59	3.74	13.58
croatia	7.63	9.15	0.66		12.46	2.08	14.03	13.04	16.12
czechia	7.61	12.54	0.29	12.63		1.92	14.07	9.76	14.26
slovakia	9.64	6.18	4.63	0.51	4.25		4.48	2.93	1.89
slovenia	4.98	10.05	4.88	12.57	12.83	1.71		14.43	14.56
bulgaria	7.17	9.15	1.29	16.01	10.52	1.43	17.53		7.94
poland	5.45	10.29	3.45	16.1	14.73	2.3	15.69	7.53	

Figure A14. Comparison of spillover tables for monthly and quarterly data, standard deviation series. Source: author's calculation. Note: values on the main diagonal (spillovers within the same market) are deleted so that the intensity of spillovers between markets can be seen. Values start from 0 (dark green), and the higher the value is, the green color gets lighter to white and to light red, and finally dark red for the highest values in individual table.

Monthly	serbia	romania	bih	croatia	czechia	slovakia	slovenia	bulgaria	poland
serbia		0.79	0.41	0.9	2.06	1.21	0.84	5.26	0.82
romania	0.25		1.01	6.39	1.09	5.58	2.66	3.36	3.97
bih	0.41	4.02		3.61	2.22	1.26	0.34	0.64	2.25
croatia	0.13	7.39	2.3		3.86	3.02	3.7	3.3	8.96
czechia	1.91	1.68	1.66	3.76		0.28	1.11	0.49	4.52
slovakia	0.76	5.7	0.64	0.12	0.61		2.57	1.91	0.64
slovenia	2.48	4.23	0.12	5.12	1.19	0.67		6.57	3.13
bulgaria	1.11	8.03	0.87	5.82	0.39	1.26	6.9		2.71
poland	0.6	5.25	1.92	10.53	3.38	0.84	2.98	2.79	
Quarterly	serbia	romania	bih	croatia	czechia	slovakia	slovenia	bulgaria	poland
serbia		6.98	12.03	0.99	1.41	1.72	1.51	0.82	0.57
romania	5.08		5.82	6.24	14.1	13.12	3.78	0.3	5.66
bih	2.12	0.91		5.27	7.09	3.13	2.61	0.66	2.1
croatia	3.72	6.58	9.27		2.99	2.8	13.7	9.6	9.58
czechia	1.71	8.44	6.54	1.03		22.73	5.5	5.02	2.54
slovakia	4.94	12.14	0.26	1.79	22.19		0.97	5.44	10.01
slovenia	2.26	5.38	3.55	14.36	4.28	4.77		13.88	11.68
bulgaria	1.38	1.38	0.09	10.31	4.23	5.27	11.65		10.91
poland	0.46	4.15	0.1	9.06	1.12	0.49	16.49	4.65	

Figure A15. Comparison of spillover tables for monthly and quarterly data, skewness series. Source: author's calculation. Note: values on the main diagonal (spillovers within the same market) are deleted so that the intensity of spillovers between markets can be seen. Values start from 0 (dark green), and the higher the value is, the green color gets lighter to white and to light red, and finally dark red for the highest values in individual table.

Monthly	serbia	romania	bih	croatia	czechia	slovakia	slovenia	bulgaria	poland
serbia		0.68	5.36	0.82	1.66	1.46	3.6	0.59	1.23
romania	1.31		4.56	7.84	1.76	2.49	1.82	1.52	1.86
bih	2.88	5.59		2.78	4.6	1.13	4.16	1.02	2.69
croatia	5.95	6.48	2.12		1.54	1.17	4.07	0.49	7.69
czechia	6.79	0.45	4.81	1.66		0.22	0.18	1.84	4.44
slovakia	1.04	3.08	0.31	2.34	0.64		5.15	2.15	0.57
slovenia	3.25	0.85	0.25	5.25	2.2	3.16		0.08	0.11
bulgaria	0.96	0.56	1.1	1.09	3.81	1.63	2.77		2.38
poland	3.02	1.64	2.75	7.43	6.71	0.32	0.55	1.7	
Quarterly	serbia	romania	bih	croatia	czechia	slovakia	slovenia	bulgaria	poland
serbia		4.17	4.16	6.42	32.5	16.37	5.57	0.92	8.11
romania	16.02		14.68	5.61	17.08	13.92	7.43	2.27	9.34
bih	13.36	12.95		1.34	6.84	12.01	6.36	4.04	8.19
croatia	8.33	5.6	11		18.9	20.7	4.9	5.59	9.3
czechia	15.26	3.14	5.85	5.12		15.65	9.82	4.51	6.85
slovakia	2.03	3.2	14.85	1.99	16.08		8.89	3.35	6.56
slovenia	6.41	4.65	12.68	5.47	11.31	9.12		3.32	6.37
bulgaria	8.1	2.72	13.72	8.52	11.01	11.1	6.53		7.31
poland	19.98	3.23	5.14	6.99	30.87	14.62	6.43	2.03	

Figure A16. Comparison of spillover tables for monthly and quarterly data, kurtosis series. Source: author's calculation. Note: values on the main diagonal (spillovers within the same market) are deleted so that the intensity of spillovers between markets can be seen. Values start from 0 (dark green), and the higher the value is, the green color gets lighter to white and to light red, and finally dark red for the highest values in individual table.

Return	Serbia	Romania	BiH	Croatia	Czechia	Slovakia	Slovenia	Bulgaria	Poland
Serbia	45.99	7.78	3	14.01	9.86	0.65	9.34	6.07	3.3
Romania	6.92	49.85	0.95	11.21	12.03	0.36	9.55	2.38	6.76
BiH	4.1	1.67	80.56	3.96	1.66	2.46	3.56	0.86	1.17
Croatia	10.54	10.31	2.12	47.02	7.43	0.83	10.51	4.97	6.29
Czechia	8.9	9.56	0.84	6.59	41.7	0.33	13.06	3.45	15.57
Slovakia	1.52	1.38	2.24	1.51	1.87	84.54	2.75	2.33	1.85
Slovenia	8.52	7.66	1.89	9.86	13.83	0.52	41.79	6.72	9.2
Bulgaria	8.35	2.58	0.78	6.6	4.74	1.83	9.56	60.03	5.54
Poland	3.31	5.94	0.62	6.34	18.09	1.13	11	5.32	48.24

Return	Serbia	Romania	BiH	Croatia	Czechia	Slovakia	Slovenia	Bulgaria	Poland
Serbia	2.44	−1.12	−1.07	−2.48	0.36	0.24	0.72	−0.11	1.01
Romania	0.26	0.98	0.23	−0.53	2.2	−0.33	−0.97	−1.31	−0.54
BiH	−1.64	−1.12	−3.12	4.75	2.8	−1.27	−1.54	−0.52	1.65
Croatia	−0.76	−1.05	1.07	−1.5	1.31	−0.61	1	−0.18	0.69
Czechia	0.55	0.45	−0.51	1.01	−1.96	0.14	−0.04	−0.15	0.5
Slovakia	−0.74	−0.47	−0.84	−0.38	−0.57	2.59	0.74	0.64	−0.96
Slovenia	1.46	−1.26	3.89	0.72	−1.13	−0.21	−3.44	−0.63	0.6
Bulgaria	−0.35	−1.31	0.13	0.31	0.31	−0.64	0.27	0.01	1.26
Poland	0.71	−0.71	1.79	0.91	0.44	−0.18	0.93	−0.6	−3.28

Figure A17. Spillover table for TVP-VAR model (upper panel) and differences between spillover values of the original spillover table and the TVP-VAR case (lower panel), return series. Source: author's calculation.

Return	Serbia	Romania	BiH	Croatia	Czechia	Slovakia	Slovenia	Bulgaria	Poland
Serbia	40.45	11.32	1.23	8.48	11.45	1.2	8.54	5.47	11.85
Romania	8.15	33.34	1.65	10.74	13.91	0.61	10.17	7.16	14.26
BiH	2.25	5.66	80.74	2.72	0.69	1.47	1.5	1.07	3.9
Croatia	4.9	9.38	2.12	31.26	12.37	0.33	14.09	10.24	15.31
Czechia	7.43	12.33	0.85	12.35	28.93	0.39	13.07	7.94	16.71
Slovakia	2.73	2.38	1.25	3.44	2.09	82.37	1.82	1.08	2.83
Slovenia	5.19	8.92	1.99	14.04	13.82	0.26	30.19	14.24	11.34
Bulgaria	4.12	8.17	1.84	12.46	10.26	0.48	17.84	38	6.83
Poland	7.28	12.11	1.59	14.9	17.04	0.32	10.9	5.17	30.7

Return	Serbia	Romania	BiH	Croatia	Czechia	Slovakia	Slovenia	Bulgaria	Poland
Serbia	20.41	−2.77	0.67	−4.29	−7.38	4.6	−4.16	−2.19	−4.88
Romania	−3.3	15.27	0.35	−5.64	−4.77	7.28	−1.23	−2.5	−5.44
BiH	0.32	0	5.18	−2.21	0.7	1.21	−1.01	−0.75	−3.44
Croatia	−2.82	−4.78	2.03	11.87	−2.89	3.23	−1.16	−2.24	−3.24
Czechia	−4.41	−4.83	0.02	−3.26	15.75	0.42	2.81	−1.39	−5.11
Slovakia	3.46	1.95	−0.91	0.93	−1.19	−3.52	−0.88	−0.22	0.39
Slovenia	−3.11	−2.49	3.34	−1.08	−2.13	1.42	8.04	−1.65	−2.33
Bulgaria	−2.01	−3.05	0.16	−1.45	−3.24	1.97	−1.27	14.79	−5.91
Poland	−2.5	−5.25	7.05	−2.55	−3.59	1.96	−0.43	−4.55	9.84

Figure A18. Spillover table for TVP-VAR model (upper panel) and differences between spillover values of the original spillover table and the TVP-VAR case (lower panel), standard deviation series. Source: author's calculation.

Return	Serbia	Romania	BiH	Croatia	Czechia	Slovakia	Slovenia	Bulgaria	Poland
Serbia	87.47	0.79	1.22	0.83	2.23	2.29	1.26	2.88	1.03
Romania	0.77	74.87	0.94	5.29	0.68	4.79	2.87	5.18	4.61
BiH	0.38	2.06	86.44	2.64	2.08	1.52	1.29	2.21	1.38
Croatia	0.69	5.65	1.81	71.56	3.46	1.86	4.12	3.24	7.61
Czechia	3.88	1.08	3.12	4.19	82.13	0.83	1.07	0.65	3.07
Slovakia	1.01	3.76	1.16	0.34	0.54	90.55	1.2	1.12	0.33
Slovenia	1.68	5.22	1.02	5.04	1.05	1.58	76.53	5.19	2.69
Bulgaria	1.28	5.76	2.16	4.49	0.6	1.08	8.49	71.64	4.51
Poland	2.13	6.75	3.67	13.03	1.47	1.11	1.94	5.03	64.86

Return	Serbia	Romania	BiH	Croatia	Czechia	Slovakia	Slovenia	Bulgaria	Poland
Serbia	0.24	0	−0.81	0.07	−0.17	−1.08	−0.42	2.38	−0.21
Romania	−0.52	0.82	0.07	1.1	0.41	0.79	−0.21	−1.82	−0.64
BiH	0.03	1.96	−1.17	0.97	0.14	−0.26	−0.95	−1.57	0.87
Croatia	−0.56	1.74	0.49	−4.22	0.4	1.16	−0.42	0.06	1.35
Czechia	−1.97	0.6	−1.46	−0.43	2.47	−0.55	0.04	−0.16	1.45
Slovakia	−0.25	1.94	−0.52	−0.22	0.07	−3.50	1.37	0.79	0.31
Slovenia	0.8	−0.98	−0.9	0.08	0.14	−0.91	−0.04	1.38	0.44
Bulgaria	−0.17	2.27	−1.29	1.33	−0.21	0.18	−1.59	1.26	−1.8
Poland	−1.53	−1.5	−1.75	−2.5	1.91	−0.27	1.04	−2.24	6.86

Figure A19. Spillover table for TVP-VAR model (upper panel) and differences between spillover values of the original spillover table and the TVP-VAR case (lower panel), skewness series. Source: author’s calculation.

Return	Serbia	Romania	BiH	Croatia	Czechia	Slovakia	Slovenia	Bulgaria	Poland
Serbia	84.72	1.41	5.62	0.79	1.99	1.57	2.54	0.67	0.7
Romania	1.82	78.85	5.13	6.13	1.52	1.3	0.95	2.06	2.24
BiH	2.91	2.51	79.73	3.02	3.89	1.71	1.84	2.01	2.38
Croatia	4.24	5.37	4.64	68.42	1.72	1.54	4.01	1.65	8.43
Czechia	8.06	1.25	4.48	1.85	75.71	1.16	0.87	2.38	4.22
Slovakia	0.91	1.8	1.03	1.62	0.37	89.34	2.34	1.88	0.71
Slovenia	2.95	1.03	2.75	5.01	1.36	2.93	81.43	1.17	1.36
Bulgaria	1.7	1.77	3.02	2.08	3.46	1.98	2.15	82.06	1.78
Poland	1.21	2.82	3.13	9.43	5.34	1.14	1.36	2.67	72.91

Return	Serbia	Romania	BiH	Croatia	Czechia	Slovakia	Slovenia	Bulgaria	Poland
Serbia	−0.12	−0.73	−0.26	0.03	−0.33	−0.11	1.06	−0.08	0.53
Romania	−0.51	−2	−0.57	1.71	0.24	1.19	0.87	−0.54	−0.38
BiH	−0.03	3.08	−4.58	−0.24	0.71	−0.58	2.32	−0.99	0.31
Croatia	1.71	1.11	−2.52	2.06	−0.18	−0.37	0.06	−1.16	−0.74
Czechia	−1.27	−0.8	0.33	−0.19	3.9	−0.94	−0.69	−0.54	0.22
Slovakia	0.13	1.28	−0.72	0.72	0.27	−4.62	2.81	0.27	−0.14
Slovenia	0.3	−0.18	−2.5	0.24	0.84	0.23	3.43	−1.09	−1.25
Bulgaria	−0.74	−1.21	−1.92	−0.99	0.35	−0.35	0.62	3.63	0.6
Poland	1.81	−1.18	−0.38	−2	1.37	−0.82	−0.81	−0.97	2.98

Figure A20. Spillover table for TVP-VAR model (upper panel) and differences between spillover values of the original spillover table and the TVP-VAR case (lower panel), kurtosis series. Source: author’s calculation.

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