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CO-MOVEMENT OF EUROPEAN STOCK MARKETS DURING PERIODS OF CRISIS: COMPARISON OF 2007–2008 AND 2020-2021

Bachelor's Thesis

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I have written this homework independently. Any ideas or data taken from other authors or other sources have been fully referenced.

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Introduction

Stock markets are very significant, as they can be utilized by investors to increase the value of their invested capital over time. However, when choosing investments, studying how different stock markets are related to each other is critical, as globalization seems to have set stock markets on a trajectory of ever-increasing integration (Thalassinos, E., & Thalassinos, P 2006). Furthermore, it seems as if the trend of increasing integration has led to national stock market returns becoming more correlated. Berben & Jansen (2005) found that the degree of co-movement amongst international stock markets has increased over the last twenty years, resulting in increased sensitivity of domestic stock markets to economic disturbances originating from foreign stock markets. This information is highly relevant to investors who wish to invest their assets for a specific level of risk. Ripley (1973, p. 356) states that, "covariation between stock prices in different countries is of interest to individual investors who wish to allocate their investment portfolios so as to maximize the rates of return on their portfolios for a given risk." This point is reiterated by (Graham et al., 2012), who confirm that the analysis of co-movement in equity markets is important in the context of asset allocation and risk management. In an environment of increasing co-movement of national stock markets, investors can use portfolio theory to identify opportunities for risk management. According to Modern Portfolio Theory, investors seeking to diversify their portfolios or manage their portfolio's risk adjusted return should identify securities, sectors, or assets classes which are negatively correlated with each other (Westfall, 2022). Furthermore, through correlation analysis of stock market price movements, the degree of co-movement among different national stock markets can be obtained (Chen et al., 2022). By obtaining an understanding of which stock markets co-move and to what degree, investors can make prudent decisions regarding portfolio diversification and manage their risk.

Determining the co-movement of stock markets while investing is similarly very relevant in the context of the modern-day Europe. After a tumultuous first half of the 20th century, the European Union was formed, and many countries have adopted the Euro. The result is an economic system which appears to be very uniform. Stoupos & Kiohos (2021) found that the creation of the Eurozone has led to increased integration of European stock markets as a single currency, central bank, and low interest rates has allowed for investors to experience a similar discount rate for their future cash flows across European stock markets. Additionally, Thalassinos, E., & Thalassinos (P. 2006) states, "the foundation and the establishment of EMU (European Monetary Union) in 1999

commenced an era where both monetary and fiscal policies in the Eurozone became more coordinated." According to (Ripley 1973, p. 358), "countries whose incomes move in a similar manner may have stock prices that also move in unison." Therefore, academic literature implies that due to the shared currency, monetary, fiscal, and economic conditions, European stock market prices should tend to move similarly and that in many European stock markets, investors should expect a similar discount rate on future cash flows. However, academic literature has also shown that in certain circumstances European stock markets have become less integrated. For example, a recent study found that the 2008 financial crisis and the 2010 debt crisis actually led to financial disintegration of the Eurozone. This manifested through the core European Union countries experiencing a relatively quick recovery in their stock markets while EU members considered to be periphery experienced slower recovery. (Stoupos & Kiohos, 2021)

The aim of this thesis is to assess the degree of pairwise co-movement between European stock markets during two periods of crisis, from 2007-2008 and 2020-2021. For the purpose of this paper, a period of crisis is defined as any event which causes a "rapid and often unanticipated drop in stock prices" (Chen, 2022). During the first period there was a global recession and during the second period a global pandemic. During both periods there were major downturns in equity markets across the globe, thus making them suitable periods for analysis. The goal of this research is to provide insight into potential diversification options for investors by outlining which European stock markets have co-moved and to what degree during previous periods of crisis. To achieve this aim, the research tasks are as follows:

- Discuss the concepts of stock market integration and stock market co-movement,
- Summarize the factors affecting stock market co-movement,
- Provide an overview of the relevant previous empirical studies,
- Select methodology and collect data,
- Calculate correlation coefficients of daily returns for both periods,
- Present and discuss the results of empirical analysis.

This paper adds to the existing literature by using a very large sample size of both EU and non-EU countries, as well as analyzing two periods instead of one.

The structure will contain two main parts, the theoretical chapter, and the empirical chapter. The theoretical chapter will first define the concepts of stock market integration and co-movement as well as which factors affect stock market co-movement. Secondly, an overview of

similar empirical studies and their findings will be given. The empirical portion will follow, where the study of the co-movement of European stock markets during 2007–2008 and 2020-2021 will be completed. This will be accomplished by obtaining the daily close prices of sample European stock exchanges, which will then be used to calculate the daily continuously compounding rate of return, from which the degree of pairwise co-movement for the set period can be obtained through the use of the Pearson coefficient. Finally, the results of the empirical study will be presented, and a conclusion will be provided where the key findings are discussed.

Keywords: stock market integration, stock market co-movement, stock market crisis, European stock markets.

1. Co-movement of stock markets during crises

1.1. The concepts of stock market integration and stock market co-movement

In this section, the concepts of stock market integration and co-movement will be given on the basis of previous academic literature. Additionally, factors which affect stock market co-movement will be examined. When researching the relationships that national stock markets have with one another, the terms co-movement and integration seem to be used almost interchangeably. However, according to Dorodnykh (2014), integration of stock markets is used as a broader term which indicates macroeconomic connectedness between countries, which can manifest in similar stock market price movements. The following is a table comparing different definitions of stock market integration.

Table 1.

Definitions of stock markets' integration

Author(s)	Definition of Stock Markets' Integration
Chen and Knez (1995), Pieper and Vogel (1997)	"Markets where investors can, in one country, buy and sell without restriction equities that are issued in another country and as a result identical securities are issued and traded at the same price across markets after adjustment for foreign exchange rates."
Korajczyk (1999)	"In financially integrated stock markets, the price of risk should be the same across markets."
Bekaert and Harvey (2003)	"In integrated equity markets, domestic investors are able to invest in foreign assets and foreign investors in domestic assets; hence, assets of identical risk command the same expected return, regardless of trading location."
Bhalla and Shetty (2006)	"Events in one country will have impacts felt in the financial markets of other countries."
Nardo et al., (2021)	"Integration in a given market for financial instruments is achieved when all market participants…(i) face identical rules when they decide to deal with those financial products; (ii) have equal access to them; and (iii) are treated equally when active in the market."

Source: Compiled by author as cited in Dorodnykh (2014).

In the above definitions, some trends are apparent. First of all, Korajczyk (1999) and Bekaert and Harvey (2003) define stock market integration in terms of risk adjusted return. More specifically, in integrated stock markets, investors should earn the same return for the given risk of an investment. Chen and Knez (1995), Pieper and Vogel (1997), Nardo et al., (2021), and Bekaert and Harvey (2003) state that in integrated financial markets, domestic and foreign investors should have the same level of access to equity markets and there should be no price discrimination for foreign investors. Bhalla and Shetty's (2006) definition is unique in this set, as no mention of access to equity markets nor risk adjusted rate of return is made. However, events

in one country affecting the financial markets of integrated economies can be interpreted as affecting the rate of return investors will earn. For example, according to this definition, if there is a booming economy and stock prices in country A are rising, then if country B has an integrated equity market, we would expect country B's stock market price movements to increase as well. Therefore, according to all of the definitions, stock market integration can be understood as investors earning a similar rate of return on their investments and having identical levels of access to financial instruments, regardless of location.

Stock market co-movement has garnered much attention from the academic community (Berben & Jansen, 2005), (Cagliesi & Guidi, 2021). In contrast to integration, co-movement is a fairly specific term. Definitions in academic literature do not vary in the same way that the definitions for integration do. Co-movement is a narrower term which encompasses the strength of correlation between the price movement of pairwise national stock markets Karolyi and Stulz (2001), Longin and Solnik (1995), Berben and Jansen (2005). In more simple terms, co-movement can be understood as correlation. In terms of stock market integration, co-movement is a measurable metric through which the degree of integration between national stock markets can be observed.

Table 2.

Definitions of co-movement

Author(s)	Definition of Co-movement
Longin and Solnik (1995)	"An increase in the correlation of stock returns over a given period"
Karolyi and Stulz (2001)	"Correlations between equity markets"
Berben and Jansen (2005)	"Correlation between returns of equity markets between a given period"

Source: compiled by author as cited in Dorodnykh (2014).

In studies searching for integration of stock markets, the degree of co-movement is obtained through the use of correlation coefficients and then the reason for the perceived integration is attributed to certain independent variables. Attributing the integration of stock markets to certain independent variables requires complex econometric models and is beyond the scope of the aim of this paper. Thus, in the empirical portion, only the degree of co-movement will be assessed. If the degree of co-movement is known, it is not necessary to understand the

exact reasons why certain markets are integrated in order to make prudent diversification decisions on the basis of Modern Portfolio Theory.

In the following paragraphs, an overview of academic literature pertaining to integration and co-movement of stock markets will be given. The first study, "Systematic Elements in the Linkage of National Stock Market Indices" written by Duncan M. Ripley in 1973, published in the MIT press, gives a theoretical background on how to measure the covariation of different countries' stock markets. The second study, "Stock Markets' Integration Analysis" written by Eleftherios Thalassinos and Pantelis E. Thalassinos in 2006, published in the European Research Studies Journal, discusses the integration of European stock markets since the creation of the European Union. Lastly, a 2015 paper by Sónia R.Bentes appearing in Physica A titled, "On the integration of financial markets: How strong is the evidence from five international stock markets?" studies the integration of 5 major countries' stock markets. As European markets are included in this study, this gives a global context to our understanding of European stock market integration. Together, these empirical studies give an understanding of the theory, using mostly European markets.

In terms methodology, there are a number of differences amongst the studies. The first difference is that all of the studies rely on data from different time periods. These time periods range from the late 20th century to the mid 2000's. More specifically, the studies' publication dates and subsequent observation dates range from 1960 – 2015. Even though the topic of co-movement amongst equity markets has been of great interest to researchers (Dorodnykh, 2014), it will be valuable to analyze and compare contemporary stock market data in order to be able to make prudent diversification decisions in the current market conditions, as the findings of past studies may no longer hold true do to changing economic conditions over time. Another difference can be found in the sample sizes and composition of each study. The variations in sample size, composition, and observation date range are listed in the table below. Ripley (1973) has the largest sample size, with 20 countries represented, 13 of which are European. (Thalassinos, E., & Thalassinos, P. 2006) have a sample size of 13, of which all are European countries. (Bentes 2015) has the smallest sample size of 5, 3 of which are European countries. There is a fair amount of overlap in the countries covered by the studies, allowing for the results of each study for a given county to be compared. This is especially true for the (Ripley 1973) and (Thalassinos, E., & Thalassinos, P. 2006) studies.

Table 3.

Countries and date ranges included in relevant studies on the integration and co-movement of national stock markets

Authors	Countries Included	Observation Period
Ripley (1973)	United States, United Kingdom, Austria, Belgium, Denmark, France, Germany, Italy, Netherlands, Norway, Sweden, Switzerland, Canada, Japan, Finland, Ireland, Australia, New Zealand, South Africa	1960-1970
Thalassinos, E., & Thalassinos, P. (2006)	Belgium (BEL 20), Germany (DAX 30), Greece (ASE 20), Spain (IBEX 35), France (CAC 40), Ireland (ISEQ), Italy (MIB 30), the Netherlands (AEX), Austria (ATX), Portugal (PSI 20), Finland (FOX), Denmark (KFX), Sweden (OMX), UK (FTSE100)	1995-2004
S.R. Bentes (2015)	PSI 20 (Portugal), IBEX 35 (Spain), FTSE 100 (UK), NIKKEI 225 (Japan) and SP 500 (US)	1999-2014

Soure: compiled by author

Finally, the studies do share a significant similarity in the fact that they all test for a correlation coefficient in price movement.

The main conclusions of the studies are mostly similar. Ripley (1973) found that the more open a stock market is to foreign capital flows, the more correlated the security prices will be to other markets. This implies that countries who trade with one another should see more correlation in stock market price movement. Furthermore, Ripley (1973) found that Finland and Denmark had close to 70% unique stock market price movement, whereas Switzerland and the Netherlands have less than 30% unique stock market price movement, and German and UK stock markets demonstrate 55% unique price movement. This means that if an investor was looking to diversify his portfolio, a stock market with high unique stock market price movement such as Finland or

Denmark could be a place to search for investments. An investor could also try to identify ETF's that track the movement of these national indexes. However, as this data is quite old (1960-1970) these results need revisiting. Thalassinos, E., & Thalassinos, P. (2006) similarly found that foreign capital flow will affect the correlation of stock market price movements but also found that the adoption of the EMU (Economic and Monetary Union) did not uniformly make European stock markets more integrated. The study noted that the relative development of different stock markets and economies could be attributed to this finding. This study also indicates that even though European countries are largely beholden to similar economic policy, stock market co-movement varies based on different factors. This finding also is helpful, as it indicates that diversification options exist amongst different European markets, even after the creation of the EMU and despite the seemingly highly connected European economy. Finally, Bentes, S.R. (2015) found that in the long-term the sample study showed integration, but the price movements of stock markets in the short term greatly vary. In regard to this study, 3/5 markets were of highly developed economies (US, UK, Japan) and thus we can assume they have a high rate of foreign capital in their markets. As we know from (Thalassinos, E., & Thalassinos, P. 2006) and (Ripley 1973), high levels of foreign capital can result in stronger stock market price correlation. It is also worth noting the comparatively small study size of five equity markets. Therefore, the conclusion of a long-term trend of increasing integration may be true in the context of highly developed stock markets, but may prove false in the context of smaller, less developed stock markets.

In conclusion, the academic literature suggests that integration can be understood as the interconnectedness of national stock markets based on macroeconomic factors such as foreign capital flows, use of the same currency, similar interest rates, degree of foreign direct investment, and similar monetary and fiscal policy (Nardo et al., 2021). Co-movement is best defined as correlation and can be understood as an indicator of integration, as academic studies have found that the more integrated economies show higher levels of co-movement in stock markets (Büttner & Hayo, 2011). The literature has also highlighted the diversification potential that exists in stock markets which show high levels of unique price movement (Ripley 1973), (Nardo et al., 2021). However, these studies all have focused simply of the essence of integration and co-movement amongst national stock markets. Thus, in the next section an overview of earlier academic literature on the topic of co-movement of European stock markets during periods of crisis will be provided.

1.2. The co-movement of European stock markets during crises – results of earlier studies

In this section, an overview of earlier empirical studies related to the co-movement of European stock markets during times of crisis will be given. In order to meet the criteria for analysis, the study had to be published within 2012-2022, include mostly European markets or indices, and cover a period of crisis or stock market downturn. Most of the studies analyzed in this section will explicitly cover how European markets behave relative to one another in times of crisis, however a study will be included which is broader in nature, covering international equity market co-movement in terms of business cycles. The first study to be covered, published by (Nikkinen et al., 2020) provides an overview of how the 2007–2009 Global Financial Crisis impacted the linkages of both core and periphery European stock markets. This study also provides very relevant analysis on how stock market linkages affect diversification potential. The second study to be covered, published by (Stoupos & Kiohos, 2021) discusses how the 2010 debt crisis impacted the integration of Euro area stock markets. The third study to be covered, published by (Ahmad et al., 2021) gives an overview of how the outbreak of Covid-19 impacted US, UK, and EU stock markets. The fourth study included, published by (Dias & Ramos, 2013) discusses how Eurozone stock markets are synchronized during bull and bear markets. This study provides great insight into co-movement of European equity markets, albeit not in the context of a specific crisis. However, the bear market analysis gives insight into how European markets co-move during times of downturn in equity markets. Through comparing these studies, an understanding should be gained of how European markets have co-moved during periods of crisis or economic downturn.

In terms of the methodology, there are a number of similarities and differences between the studies. For example, when choosing indices to examine, only (Nikkinen et al., 2020) includes "frontier" stock markets of Croatia, Estonia, Romania, Slovenia, and Slovakia. This is in contrast to (Stoupos & Kiohos, 2021), (Ahmad et al., 2021), and (Dias & Ramos, 2013), all of which focus on more developed Western, Southern, and some Central European countries. When the results are interpreted together, these studies allow for a more encompassing understanding of European stock market co-movement during periods of crisis. In terms of observation periods, the dates range from 1997 to March 2020. Another point of interest is the method used by each study to calculate the co-movement of stock markets. It is worth noting that all of the studies employ different types of complicated models in order to reach their results. The reason for this is that these studies do not simply wish to obtain the levels of co-movement between national equity

markets. The authors of the studies wish to attribute the co-movement of national stock markets to specific factors. This results in the use of complex econometric models that are beyond the scope of this paper. However, it is important to note that all of the studies utilize the weekly close price for the stock indices to obtain the necessary correlation coefficients for determining co-movement of stock markets. Below is a table outlining the methodology and findings of the aforementioned empirical studies.

Table 4.

Comparison of prior studies on the co-movement of European stock markets during periods of crisis

Authors	Event	Stock Markets	Result
Nikkinen et al., (2020)	2008–2009 global financial crisis	Croatia (CROBEX), Romania (BET), Estonia (OMX Tallinn), Slovakia (SAX), Slovenia (SBI20), the United States (S&P 500), the United Kingdom (FTSE100), and Germany (DAX)	EU periphery markets show low co-movement, providing a possibility for portfolio diversification.
Stoupos & Kiohos (2021)	2010 sovereign debt crisis	France, Austria, Belgium, Finland, the Netherlands, Luxembourg, Cyprus, Greece, Ireland, Italy, Malta, Portugal and Spain	Stock market integration is strong amongst core member-states but is divergent amongst periphery Eurozone members.
Ahmad et al., (2021)	2020 covid-19 market crash	United States (S&P500), United Kingdom (FTSE100), Europe (S&P Europe)	US, UK, and European stock markets had similar responses to covid-19 outbreak, but severity was asymmetric.
Dias & Ramos (2013)	Bull and Bear cycles	Austria, Belgium, Finland, France, Germany, Ireland, Italy, the Netherlands, Portugal, and Spain	Core member -states show higher level of synchronization with bull and bear cycles, whereas periphery show low synchronization with core-member states

Source: Compiled by author.

In terms of how European stock market have previously performed during periods of crisis, it is clear that some trends exist in the academic literature. For example, (Stoupos & Kiohos, 2021)

and (Nikkinen et al., 2020) found that in the global financial crisis of 2008 and in the sovereign debt crisis of 2010 stock market co-movement was low amongst periphery EU members and high amongst core EU members. Nikkinen et al. (2020) added that this phenomenon of low stock market co-movement amongst periphery EU members possibly allows for diversification, whereas (Stoupos & Kiohos, 2021) do not make this claim outright. As these studies analyze different crises, a trend is formed of periphery EU stock markets providing diversification potential during periods of crisis. One limitation of this conclusion is that the data is over a decade old, and thus an example from a recent example is necessary. A study by Ahmad et al., (2021) which studied the effect of the Covid-19 market crash found that US, UK, and European stock markets had similar responses, but the severity was asymmetric. It is worth noting that in this study, the ETF used to represent Europe (S&P Europe 350) according to its own prospectus, "consists of 350 leading blue-chip companies drawn from 16 developed European markets." These markets include Austria, Belgium, Denmark, Finland, France, Germany, Ireland, Italy, Luxembourg, the Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, and the United Kingdom. While this ETF consists of some markets considered as periphery by (Stoupos & Kiohos, 2021), it does not include any frontier markets used in (Nikkinen et al., 2020). Furthermore, the index weight of periphery members is quite small, for example Portugal with only a 0.2% weight. Therefore, the findings by (Ahmad et al., 2021) provides limited contemporary evidence that there exists asymmetry in how stock markets react in periods of crisis, although larger trends may stay similar in larger, more developed markets. It would be interesting to see how this finding would have changed if the periphery and frontier markets in Europe had been accounted for in the study with a higher weight. Dias and Ramos (2013) found that core member states have a high level of synchronization during bull and bear cycles, whereas periphery states showed low synchronization with core states. This study indicates that periphery stock markets in the EU show more unique price movement in contrast to core member state stock markets in bull and bear cycles. This study similarly demonstrates that the unique price movement of periphery EU stock markets could provide investors with a real opportunity to diversify their portfolios to hedge against equity market downturn in bear cycles in core EU markets.

In conclusion, the academic literature shows a trend of periphery and frontier EU stock markets showing low levels of co-movement when compared to core EU member states' stock markets during periods of financial crisis and bear cycles. (Dias & Ramos, 2013), (Nikkinen et al.,

2020) As discussed in previous sections, this low level of co-movement can possibly be explained by lower macroeconomic interconnectedness of periphery economies to core European and global economies and thus having less exposure to economic contagion from foreign economies. (Stoupos & Kiohos, 2021) Furthermore, prior empirical studies have focused predominantly only one period of crisis and in terms of stock market co-movement during Covid-19, (Ahmad et al., 2021) largely excluded the periphery and frontier markets from their analysis. The empirical study to follow will address this issue by assessing the co-movement amongst European markets during two periods of crisis. This analysis will be done for a set period, from 2007-2008 and 2020–2021 and will include a large sample size of European stock indices from both EU and non-EU European countries.

2. European stock markets' co-movement during 2007-2008 and 2020-2021 – empirical analysis

2.1. Data and methodology for empirical study

First, the periods of crisis were selected. This study analyzes the 2007-2009 Global Financial Crisis as well as the Covid-19 pandemic. For the purpose of this paper, a period of crisis is defined as any event which causes a "rapid and often unanticipated drop in stock prices" (Chen, 2022). During the selected periods there were major downturns in equity markets across the globe, making them suitable periods for analysis. According to the Federal Reserve Bank of Cleveland, the period of what is widely known as the Global Financial Crisis is recorded as being from December 2007 to June 2009 (Rich, 2013). Covid-19 was declared as a pandemic by the WHO on the 11th of March 2020 (Cucinotta & Vanelli, 2020). However, finding consensus on the end date of the pandemic is not possible, as at the time of writing its effects are ongoing in other countries such as China, which has a very strict Zero-Covid policy (Mallard, 2022). As an end date is not possible determine, the period was set as follows:

- T-1: one month before the official announcement of a crisis
- T0: the official announcement date of the crisis
- T+1: one year after the announcement of the crisis

In order to keep the methodology consistent, this approach was used for both periods. This methodology has been used previously by (He et al., 2022) to analyze crisis events in stock markets. T0 allows for the exact dates of T-1 and T+1 to be determined and does not separate the

period of analysis. The unbroken period of observation is T-1 to T+1. Thus, the exact observation periods are as follows:

- Global Financial Crisis (Period 1):
    - T-1: 01.11.2007
    - T0: 01.12.2007
    - T+1: 01.12.2008
- Covid-19 Pandemic (Period 2):
    - T-1:11.02.2020
    - T0: 11.03.2020
    - T+1: 11.03.2021

Second, a sample of European countries was selected for analysis. These countries outlined in table 5 were chosen based on previous empirical studies with the goal of encompassing a greater number of both periphery and core European countries, thereby contributing to the academic literature. More specifically, the country sample is compiled based on the previous work of (Nikkinen et al., 2020), (Dias & Ramos, 2013), and (Stoupos & Kiohos, 2021). Though this sample is very similar to EU27, there are some differences. Countries such as Norway, Russia, Switzerland, and the UK have been included as they are all significant European economies. Iceland has been included to complete the representation of the Scandinavian region. Microstates such as Luxembourg and Malta have been left out of the analysis and Slovenia due to difficulties procuring price history data. Furthermore, this work provides analysis on two periods of crisis, while most of the previous literature focuses on only one. Also, this list includes four countries which did not use the Euro as the national currency in period 1, but by period 2 had adopted the Euro, which may provide insight on how or if the adoption of the Euro affects stock market co-movement. Finally, the country sample of this study includes a far greater number of countries than the studies off which the list is based.

Table 5.

Countries and the index used in analysis

Country	Index	Currency	Euro adoption
Austria	ATX	EUR	01.01.1999
Belgium	BEL	EUR	01.01.1999
Bulgaria	SOFIX	BGN	n/a
Czechia	PX	CZK	n/a
Denmark	OMXC25	DKK	n/a
Estonia	OMXT	EUR	01.01.2011
Finland	OMXH	EUR	01.01.1999
France	CAC	EUR	01.01.1999
Germany	DAX	EUR	01.01.1999
Greece	ATHENEX	EUR	01.01.2001
Hungary	BUX	HUF	n/a
Iceland	ICEX	ISK	n/a
Ireland	ISEQ	EUR	01.01.1999
Italy	MIB	EUR	01.01.1999
Latvia	OMXR	EUR	01.01.2014
Lithuania	OMXV	EUR	01.01.2015
Netherlands	AEX	EUR	01.01.1999
Norway	OSEAX	NOK	n/a
Poland	WIG	PLN	n/a
Portugal	PSI	EUR	01.01.1999
Romania	BET	RON	n/a
Russia	MOEX	RUB	n/a
Slovakia	SAX	EUR	01.01.2009
Spain	IBEX 35	EUR	01.01.1999
Sweden	OMXS	SEK	n/a
Switzerland	SMI	CHF	n/a
United Kingdom	FTSE 250	GBP	n/a

Source: compiled by author

Third, the price data for period 1 and period 2 was gathered and prepared in Excel for correlation tests. This was done by obtaining the daily close prices for each of the stock indices, which were then used to calculate the daily continuously compounding rate of return. Price data of stock indices is readily available public information, usually listed on exchanges or other financial websites. For the purpose of this paper, the price history and exchange rate data has been drawn from five websites, Nasdaq Baltic, Nasdaq Nordic, Yahoo Finance, Stooq, and the Vienna Stock Exchange. Continuous compounding uses a natural log-based formula to calculate and add back accrued interest at the smallest possible intervals. This formula is suitable for

describing historical results (Benninga & Mofkadi, 2022). Daily prices were chosen in order to allow for a larger number of observations as opposed to quarterly or annual data, which would yield too few observations for robust quantitative analysis. As there are some countries in the sample group with currencies other than the Euro, all calculations were converted in terms of the Euro to ensure comparability of results. Furthermore, only the days where trading occurred on all 27 markets were considered.

Subsequently, the Excel database containing the daily continuously compounding rates of return was exported to SPSS for correlation analysis. For the correlation analysis a parametric quantitative approach was used. This is due to the data type being numeric and the number of daily closing prices being very large, numbering 5,562 for period 1 and 5,751 for period 2. The Pearson correlation coefficient was used as it is appropriate when comparing large samples of numeric data. The confidence level used was 95%. The result is a 27x27 correlation table for periods 1 and 2 where sample stock indices' pairwise correlation coefficients are presented on a scale ranging from -1 to 1. The correlation analysis demonstrates the strength and direction of co-movement between different stock indices during times of crisis and provides the results for the discussion of results and conclusion sections. The correlation coefficients were segmented according to strength as follows:

- 0.7–0.999: strong
- 0.4–0.699: medium
- 0.1–0.399: weak
- 0–0.009: not correlated

The segments are the same for both positive and negative correlation coefficients. This methodology has been used in previous academic works on similar subjects. According to (Lee, 2021), it is possible to calculate annual realized correlations between stock markets using daily returns. Similarly, (Beine & Candelon, 2011) confirm that daily price data on stock returns of the national stock markets can be utilized in order to calculate an annual estimate of the correlation between two countries. Furthermore, according to (Chen et al., 2022), the Pearson correlation is widely used to measure co-movement among stocks. A similar article outlining the process of obtaining co-movement of pairwise stock indices by (Andersen et al., 2001) provides further theoretical background in terms of the methodology.

Lastly, the annualized returns, volatilities, and reward to risk ratios for periods 1 and 2 were calculated in Excel along with their respective averages. The annual return and volatility were calculated on the basis of the discrete return formula using monthly returns. Monthly returns were used as some gaps appeared in the daily returns due to trading not occurring on all 27 markets on each day in the period of observation. Annual returns were calculated using equation 1 (Weber, 2017, p.5).

$$\mu_A = (1 + \mu_m)^T - 1 \quad (1)$$

The annual volatilities were calculated using equation 2 (Weber, 2017, p.5).

$$\sigma_A = \sqrt{(\sigma_m^2 + (1 + \mu_m)^2)^T - (1 + \mu_m)^{2T}} \quad (2)$$

In equations 1 and 2, μ represents returns, σ represents volatility, T is equal to 12, A represents annual values, and m represents monthly values. The return to risk ratios were calculated by dividing the annualized return by the annualized volatility of a given index. The averages were calculated by using Excel function *average*. The purpose of these calculations is to give context to the correlation coefficients and a basis for comparison of the two periods.

2.2. Results of empirical analysis

The average annual return for period 1 was -53.24%. It is noteworthy that no country earned a positive annual return during the period of observation. Additionally, the range of returns is quite large, spanning from -92.46% to 20.48%. The average annual volatility was 14.11%. The volatilities were in a tighter range, with values ranging from 7.36% to 19.75%. Lastly, the average return to risk ratio for the period was -4. The range was large, spanning from -12.6 to -1.3. No country had a positive return to risk ratio for the period. The 5 countries with the highest returns for the period were Slovakia (-20.48%), Switzerland (-26.46%), Germany (37.39%), France (-40.34%), and Spain (-41.39%). Slovakia having the highest returns as well as the best return to risk ratio is a surprising result; however, this can be explained by the SAX index recording a 0% daily change in 69 out of 206 observations. Thus, it seems that this result may be explained by low trading activity rather than an equity market which shows unique price movement. The 5 countries which earned the lowest returns were Estonia (-63.74%), Russia (-64.73%), Romania (-69.10%), Bulgaria (-77.77%), and Iceland (-92.46%). These are shown below in figure 1.

Country	Annualized rate of return	Annualized volatility	Return to risk ratio
Slovakia	-20.48%	15.55%	-1.32
Switzerland	-26.46%	9.46%	-2.80
Germany	-37.93%	14.44%	-2.63
France	-40.34%	13.04%	-3.09
Spain	-41.39%	12.59%	-3.29
Denmark	-44.73%	16.28%	-2.75
Italy	-46.59%	12.07%	-3.86
Sweden	-47.63%	14.71%	-3.24
Portugal	-48.45%	13.81%	-3.51
Czechia	-48.97%	17.21%	-2.84
Finland	-49.44%	12.43%	-3.98
Netherlands	-49.88%	15.79%	-3.16
Latvia	-51.73%	12.54%	-4.13
United Kingdom	-51.77%	11.42%	-4.53
Hungary	-52.57%	18.14%	-2.90
Belgium	-53.39%	13.25%	-4.03
Poland	-54.71%	14.89%	-3.68
Norway	-58.09%	19.75%	-2.94
Austria	-58.77%	16.59%	-3.54
Greece	-61.02%	13.01%	-4.69
Lithuania	-62.59%	14.98%	-4.18
Ireland	-62.81%	10.76%	-5.84
Estonia	-63.74%	13.86%	-4.60
Russia	-64.73%	17.28%	-3.75
Romania	-69.10%	17.91%	-3.86
Bulgaria	-77.77%	11.79%	-6.59
Iceland	-92.46%	7.36%	-12.57
Average	-53.24%	14.11%	-4.0

Figure 1. Period 1 annualized rates of return, volatility, and return to risk ratio by country.

Source: author's calculations.

The correlation coefficients for period 1 showed that the majority of stock markets have a statistically significant positive correlation to one another. The results can be found in the table below.

Table 6.

Period 1 Correlations by strength

Classification	Range	Percent	Percent (only stat sig. observations)	Total
Strong Correlation	0.7–0.999	34.47%	39.41%	121
Medium Correlation	0.4– 0.699	30.2%	34.53%	106
Weak Correlation	0.1–3.99	21.94%	25.08%	77
Negative Correlation	(-0.1)-(-0.399)	0.85%	0.98%	3
Not Correlated	0–0.009	0%	0%	0
Not Statistically significant	p>0.005	12.54%	n/a	44

Source: compiled by author.

In period 1, 86.61% of sample stock market returns were positively correlated to one another. The largest segment was strong positive correlations, comprising 34.47% of the total. Second were medium strength correlations, which made up the 30.2% of the correlations. Weak correlations were third, comprising 21.94% of the correlations. Negative correlations comprised less than 1% of correlations. The correlation by country can be found below in figure 2.

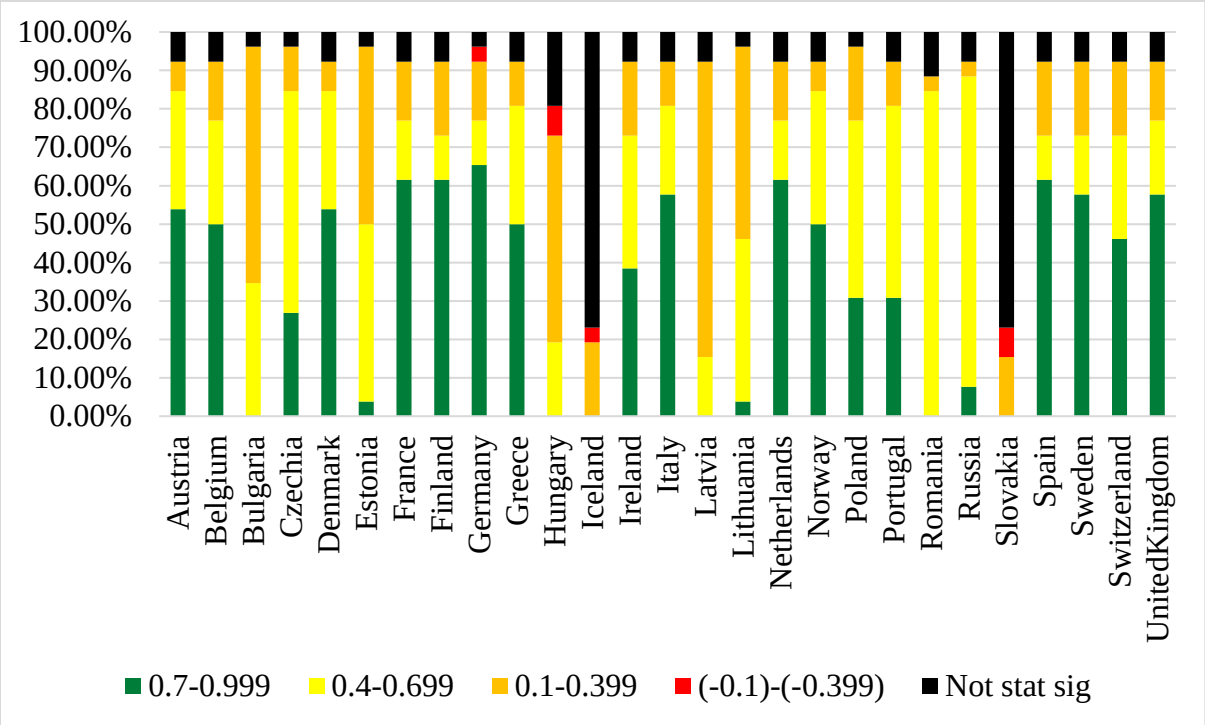

Figure 2. Period 1 correlations by country.

Source: compiled by author.

A number of countries had correlation coefficients which were larger than 0.9 indicating an almost perfect positive correlation. Some examples of this are France and Finland (0.914), France and Germany (0.952), France and Italy (0.912), France and the Netherlands (0.946), and Germany and the Netherlands (0.903). The exact correlations can be found in appendix A. The strong positive correlation of returns is primarily concentrated between Europe's more developed economies. Countries such as Bulgaria, Czechia, Estonia, Hungary, Iceland, Latvia, Lithuania, Romania, Russia, and Slovakia stand out as they generally showed a higher proportion of medium and weak correlations to other countries or had a very high percentage of statistically insignificant correlation coefficients. Finally, negative correlations were comparatively few, comprising less than 1% of correlations. All of the negative correlations were in the weak range from (-0.159) to (-0.384). Slovakia was the common country for two of these correlations, being negatively correlated with Germany (-0.159) and Hungary (-0.384). Iceland and Hungary were also negatively correlated (-0.212). Both Slovakia and Iceland had the majority of their correlation coefficients in the not statistically significant category, with both countries recording 76.92% of their correlation coefficients as statistically insignificant. It is worth mentioning that these countries were at opposite ends of the return spectrum, with Slovakia being first and Iceland being last. Another interesting result is that 4/5 of the countries with the best returns have the majority of their correlations in the strong positive category. For example, Switzerland had 46.15% strong positive correlations, Germany 65.38%, France 61.54%, and Spain 61.54%. The outlier is Slovakia, which as previously mentioned, had the majority of its correlation coefficients (76.92%) in the not statistically significant category. In terms of the worst preforming countries no such clear pattern emerged. Out of these countries, 2/5 had the majority of their correlations in the medium positive range. For example, Russia had 80.77% and Romania 84.62% in this category. Estonia had 46.15% in both the medium and weak positive ranges, Bulgaria had 61.54% in the weak positive range, and the worst preforming Iceland had 76.92% of observations in the not statistically significant range. Thus, there is not a clear trend of worst performers having the majority of their correlation coefficients in the same range as was the case with the best performing countries.

The average return for period 2 was 0.32% which is the result of about half of the countries earning a positive annual return and half of the countries earning a negative annual return. The range of returns is from -14.35% to 22.77%. Volatility was quite high across the

board with an annual average of 28.36%. Volatilities were in the range of 9.31% to 43.65%. The average annual return to risk ratio was 0.038. The return to risk ratios are quite concentrated, ranging from -0.58 to 0.82. In terms of annual returns, the 5 countries with the highest returns were Iceland (22.77%), Denmark (18.76%), Lithuania (13.45%), Sweden (12.79%), and Estonia (11.36%). It is noteworthy that the best returns were earned in the Baltics and Scandinavia, not in Europe's larger countries such as France, Germany, or the UK. The 5 countries with the lowest returns were Portugal (-9.81%), Greece (-10.11%), Bulgaria (-11.73%), Russia (-13.52%), and Spain (-14.35%). The exact results are shown in figure 3 below.

Country	Annualized rate of return	Annualized volatility	Return to risk ratio
Iceland	22.77%	40.17%	0.57
Denmark	18.76%	24.45%	0.77
Lithuania	13.45%	18.41%	0.73
Sweden	12.79%	29.90%	0.43
Estonia	11.36%	26.71%	0.43
Norway	7.98%	38.25%	0.21
Latvia	7.59%	9.31%	0.82
Finland	6.01%	29.73%	0.20
Netherlands	5.82%	27.41%	0.21
Ireland	4.89%	30.41%	0.16
Slovakia	3.13%	14.77%	0.21
Germany	2.79%	30.98%	0.09
Romania	-0.15%	22.76%	-0.01
Austria	-2.77%	37.37%	-0.07
France	-3.74%	30.02%	-0.12
United Kingdo	-4.43%	27.29%	-0.16
Poland	-5.08%	32.31%	-0.16
Switzerland	-5.27%	16.50%	-0.32
Italy	-6.02%	32.64%	-0.18
Hungary	-6.75%	31.42%	-0.21
Belgium	-7.39%	30.42%	-0.24
Czechia	-7.51%	29.41%	-0.26
Portugal	-9.81%	26.34%	-0.37
Greece	-10.11%	43.65%	-0.23
Bulgaria	-11.73%	20.06%	-0.58
Russia	-13.52%	33.58%	-0.40
Spain	-14.35%	31.46%	-0.46
Average	0.32%	28.36%	0.038

Figure 3. Period 2 annualized rates of return, volatility, and return to risk ratio by country. Source: author's calculations.

The correlation results for period 2 showed that stock markets had a strong positive correlation to one another. The results can be found in the table below.

Table 7.

Period 2 distribution of correlations by strength

Classification	Range	Percent	Percent (only stat sig. observations)	Total
Strong Correlation	0.7– 0.999	54.13%	58.28%	190
Medium Correlation	0.4–0.699	33.62%	36.2%	118
Weak Correlation	0.1– 0.399	5.13%	5.52%	18
Negative Correlation	(-0.1)-(-0.399)	0%	0%	0
Not Correlated	0–0.009	0%	0%	0
Not Statistically significant	p>0.005	7.12%	n/a	25

Source: compiled by author.

In period 2, 92.88% of observations demonstrated a positive correlation to other stock markets. Furthermore, it is interesting that over half (54.13%) of the observed positive correlations were in the strong category. Second were medium strength correlations, comprising 33.62% of the total. Weak correlations were third, making up only 5.13% of the total observations. No statistically significant negative correlations were recorded for this period. The correlation strength by country can be found below in figure 4.

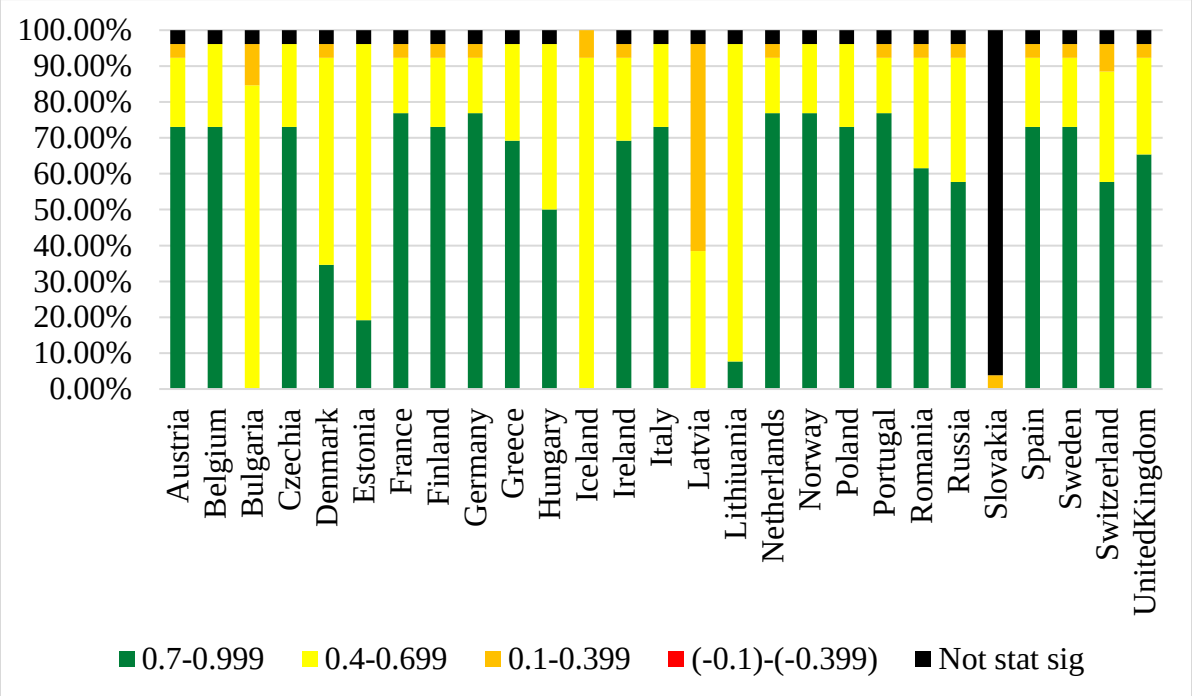

Figure 4. Period 2 correlations by country.

Source: compiled by author

A number of countries showed correlation coefficients to other markets which were greater than 0.9 indicating an almost perfect positive correlation. These almost perfect positive correlations were amongst more developed countries such as France, Germany, Italy, Belgium, the Netherlands, Spain, Sweden, and Finland. Some examples of this are France and Belgium (0.909), Belgium and Spain (0.910), France and Germany (0.958), France and Italy (0.912), France and the Netherlands (0.928), France and Spain (0.935), France and Sweden (0.902), Finland and Sweden (0.913). The exact correlations can be found in appendix B. The country with the highest number of weak correlations was Latvia, where weak positive correlations compose 57.69% of observations. Whilst the countries showing the very strong correlation coefficients of >0.9 have some degree of geographical proximity, Latvia shows only a medium correlation to its Baltic neighbors Estonia (0.562) and Lithuania (0.569). This is quite an interesting result as Estonia and Lithuania have a strong (0.854) correlation to one another. Deltuvaitė (2015) identified the same phenomenon in their study, attributing Latvia's low correlation to being less connected to foreign economies than Estonia and Lithuania. Another interesting result is that 4/5 of the countries with the best annual returns have the majority of their correlations in the medium range. For example, the percent of medium strength positive correlation for Iceland was 92.31%, Denmark 57.69%, Lithuania 88.46%, and Estonia 76.92%. The outlier was Sweden, which got the 4th best returns for the period and had 73.08% of correlations in the strong positive range. In terms of the 5 worst performing countries a pattern emerged where 4/5 had the majority of their correlations in the strong positive range. For example, Portugal had 76.92% of its correlations in this range, Greece 69.23%, Russia 57.69%, and Spain 73.08%. The outlier was Bulgaria, which had 84.62% of its correlations in the medium positive range.

2.3. Discussion of results

The results of this study are largely in line with the findings of the theoretical portion of this paper. This is due to the fact that in both periods of crisis, economically developed, core European countries' stock markets showed a consistently high level of co-movement with one another. Less economically developed, periphery economies' stock markets had a lower level of co-movement to core countries and to each other. Stoupos & Kiohos (2021), Dias & Ramos (2013) An interesting result amongst core European countries is that in both periods the proportion of correlation coefficients greater than 0.9 was quite significant. This demonstrates an

almost 1:1 co-movement of core European countries' stock markets during times of crisis. The exact correlation coefficients can be viewed in appendix A and B. According to the academic literature, this high level of co-movement amongst certain stock markets during times of crisis can be attributed to the more integrated nature of core European economies based on a number of macroeconomic factors. These macroeconomic factors include foreign capital flows, use of the same currency, similar interest rates, degree of foreign direct investment, and similar monetary and fiscal policy. (Nardo et al., 2021) On the other hand, less economically developed, periphery European countries showed weaker correlations to countries in the core and to each other. This can be explained as the result of lower integration of these economies based on the same macroeconomic factors outlined above. This phenomenon was more pronounced in period 1, as in period 2 the correlation coefficients were in the strong positive range increased significantly. However, it can still be observed that in period 2, countries such as Bulgaria, Denmark, Estonia, Iceland, Latvia, and Lithuania have the majority of their correlations in the medium positive range. This is best observed in figure 4. This study demonstrates that although co-movement of markets has become stronger and more widespread, periphery countries still show lower co-movement to other markets than core countries during times of crisis.

The comparison of period 1 and 2 allows for the observation of some interesting trends. In terms of annual returns, the main difference between periods 1 and 2 is that in period 1, no country earned a positive return whilst in period 2, 12/27 countries earned a positive annual return. In terms of volatility, period 2 interestingly was the more volatile period. Period 1 had an average volatility of 14.11% whilst period 2 had an average volatility of 28.36%. This significant difference in average returns and volatility may be due to the fact that upon the announcement of Covid-19 as a pandemic, markets fell sharply. However, many countries implemented stimulus packages to support the economy. Interest rates were also low at this time, thus allowing for a quick recovery of equity markets. This is quite different from period 1, where markets did not make such a quick recovery during the period of observation. In terms of return to risk ratios, the main difference was that period 2 had much more uniform results than period 1. In period 2, the average return to risk ratio was 0.038 with a range of -0.58 to 0.82. In period 1 the average return to risk ratio was -4 with a larger range of -12.57 to -1.32. The differences are outlined in the table below.

Table 8.

Period 1 and 2 average annualized rates of return, volatility, and return to risk ratio and the difference between the averages of periods 1 and 2

Classification	Period 1 avg.	Period 2 avg.	**Difference**
Annualized rate of return	-53.24%	0.32%	**52.92%**
Annualized volatility	14.11%	28.36%	**14.25%**
Return to Risk ratio	-4.01	0.038	**3.972**

Source: compiled by author

The correlation coefficients of period 1 and 2 both demonstrated that the majority of sample stock markets were positively correlated during both periods of crisis. Comparing the two periods shows that positive co-movement of markets has intensified. The changes between the two periods are brought out below in table 9.

Table 9.

Period 1 and 2 proportions of correlations and change from period 1 to period 2

Classification	Range	Period 1	Period 2	**Δ%**
Strong Correlation	0.7–0.999	34.47%	54.13%	**57.02%**
Medium Correlation	0.4–0.699	30.20%	33.62%	**11.32%**
Weak Correlation	0. –0.399	21.94%	5.13%	**-76.62%**
Negative Correlation	(-0.1)-(-0.399)	0.85%	0%	**-100%**
Not Correlated	0–0.009	0%	0%	**0%**
Not Statistically significant	p>0.005	12.54%	7.12%	**-43.18%**

Source: compiled by author.

From period 1 to period 2 the proportion of positive correlations increased as well as the strength of the correlations. Specifically, the proportion of strong correlations increased in period 2 by 57.02%. The proportion of medium correlations increased by 11.32% while the proportion of weak correlations decreased by 76.62%. The proportion of negative correlations decreased by 100%.

This information can be used practically, as the countries whose stock markets show less co-movement with other markets have more unique price movement and present investors with opportunities for portfolio diversification and risk management during times of crisis. (Ripley,

1973), Nikkinen et al., (2020) Simultaneously investing into countries whose stock markets co-move to a very high degree such as France and Germany may not provide an investor with actual diversification potential during a period of crisis. Apart from previous academic literature arriving at the same conclusion, Modern Portfolio Theory also provides a basis for this idea. Specifically, Modern Portfolio theory states that investors seeking to diversify their portfolios or manage their portfolio's risk adjusted return should identify securities, sectors, or assets classes which are negatively correlated with each other (Westfall, 2022). Thus, it seems prudent to combine stocks of periphery countries with stocks of core countries in order to achieve portfolio diversification.

Conclusion

The literature review demonstrated that integration of stock markets can be understood as interconnectedness based on macroeconomic factors such as foreign capital flows, use of the same currency, similar interest rates, degree of foreign direct investment, and similar monetary and fiscal policy (Nardo et al., 2021). Co-movement is best defined as correlation and can be understood as an indicator of integration, as previous studies have found that more integrated economies show higher levels of co-movement in stock markets (Büttner & Hayo, 2011). The literature has also highlighted the diversification potential that exists in stock markets which show high levels of unique price movement as opposed to countries whose stock markets show the opposite (Ripley 1973), (Nardo et al., 2021), Nikkinen et al., (2020).

Similar previous empirical research has demonstrated a trend of periphery and frontier EU stock markets showing low levels of co-movement when compared to core EU member states' stock markets during periods of crisis and bear cycles. (Dias & Ramos, 2013), (Nikkinen et al., 2020) Considering that the integration of stock markets relies on macroeconomic factors, low levels of co-movement can be explained by a lower macroeconomic connectedness of periphery economies to core European and global economies. This results in less integrated economies' stock markets having less exposure to downturns in foreign markets. (Stoupos & Kiohos, 2021) The practical takeaway is that countries whose stock markets show weak or negative co-movement with other markets present investors with opportunities for portfolio diversification and risk management during times of crisis. (Ripley, 1973), Nikkinen et al., (2020)

In the empirical portion, the daily closing prices of national stock indices were used to calculate daily rates of return. The daily rates of return were then used calculate the pairwise correlation coefficients of 27 European countries during the Global Financial Crisis and Covid-19 pandemic. The number of observations in period 1 was 5,562 and 5,751 for period 2. If necessary, daily closing prices were converted into Euro terms. The segmentation of the correlation coefficients was done in excel according to the strength and direction of the correlation coefficient. The key findings of the empirical study are as follows:

- The majority of European stock markets are positively correlated.
- Between period 1 and period 2 a higher proportion of markets became positively correlated to a stronger degree.
- Economically developed, core European countries' stock markets are almost perfectly correlated with many correlation coefficients greater than 0.9 in periods 1 and 2.
- Less economically developed periphery countries had the majority of their correlation coefficients in the weak and medium positive range, indicating more unique price movement.

The key findings of the empirical analysis were largely in line with the findings of previous academic works outlined in the theoretical portion of the thesis. This information can be used practically, as the countries whose stock markets show less co-movement with other markets have more unique price movement and present investors with opportunities for portfolio diversification and risk management during times of crisis. (Ripley, 1973), Nikkinen et al., (2020)

There are a few important limitations to the work which are worth mentioning. For example, when comparing periods 1 and 2 some sample index components and their weight may have changed. The comparison of the two periods does not take this into account. Furthermore, it was necessary to eliminate numerous observations due to trading not occurring on all markets on the same days, resulting in data loss. Furthermore, a number of countries which showed weak co-movement with the sample did so due to the illiquidity of their stock market, not due to unique price movement. Lastly, the two crises were different in nature. It is quite an important distinction that period 1 was a financial crisis and period 2 was a health crisis.

There are a few areas for future research. The first of these is how the liquidity of a stock market effects its co-movement with other markets and diversification potential. Second would

be an expansion of the current sample to a global scale where North American, South American, Middle Eastern, and Asian markets are included. This could provide investors with insight into which global markets are the co-move the most with their native country in periods of crisis.

In conclusion, through the review of academic literature, collection of data, and quantitative analysis the aim of assessing the degree of co-movement amongst European markets during two periods of crisis has been achieved. The empirical study added to the existing literature including by a large sample size of both EU and non-EU European countries and by assessing two periods instead of one. The goal of the paper has also been achieved, as European investors can access the provided correlation data to find markets with show lower co-movement to their home country's market to identify possible opportunities for portfolio diversification.

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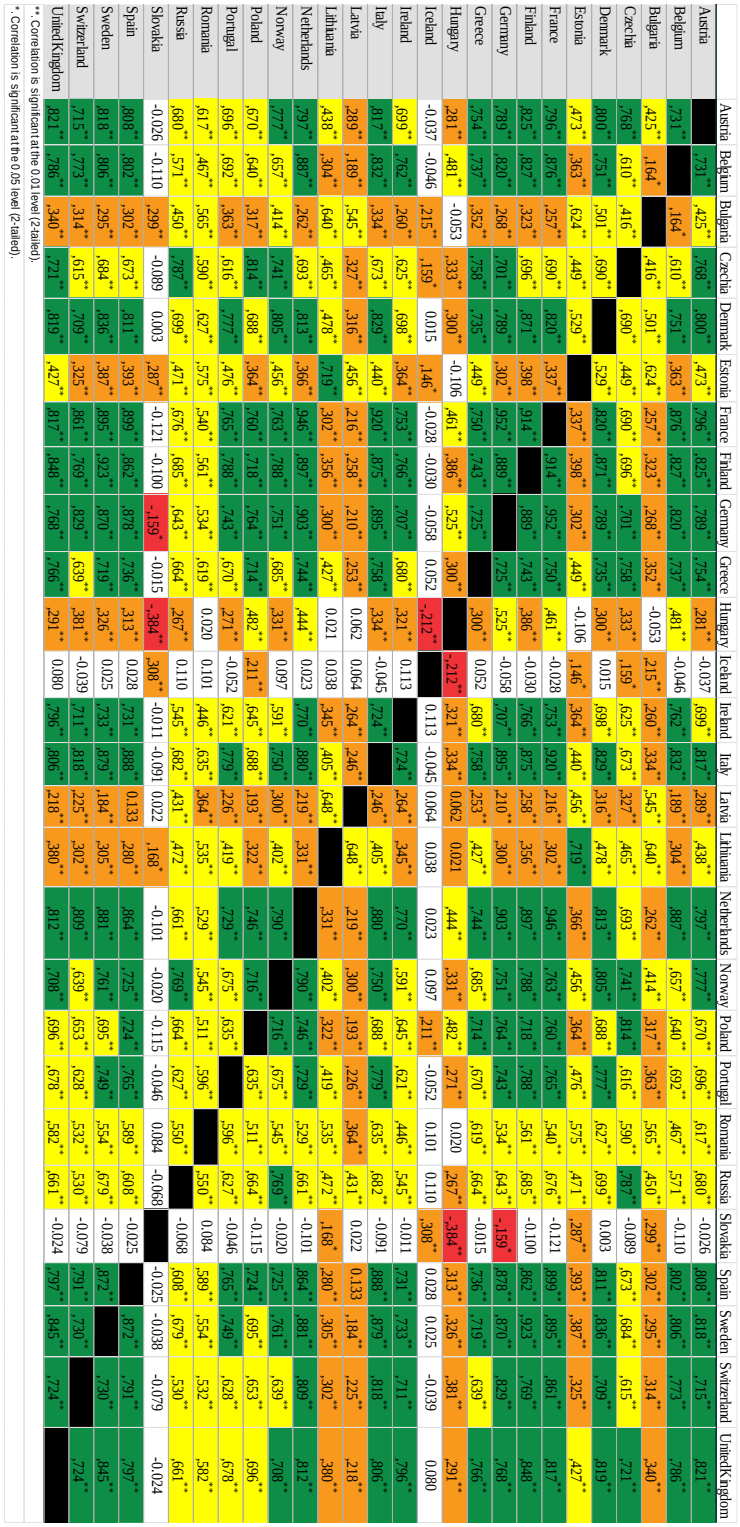
Appendix A

Correlation coefficients for period 1.



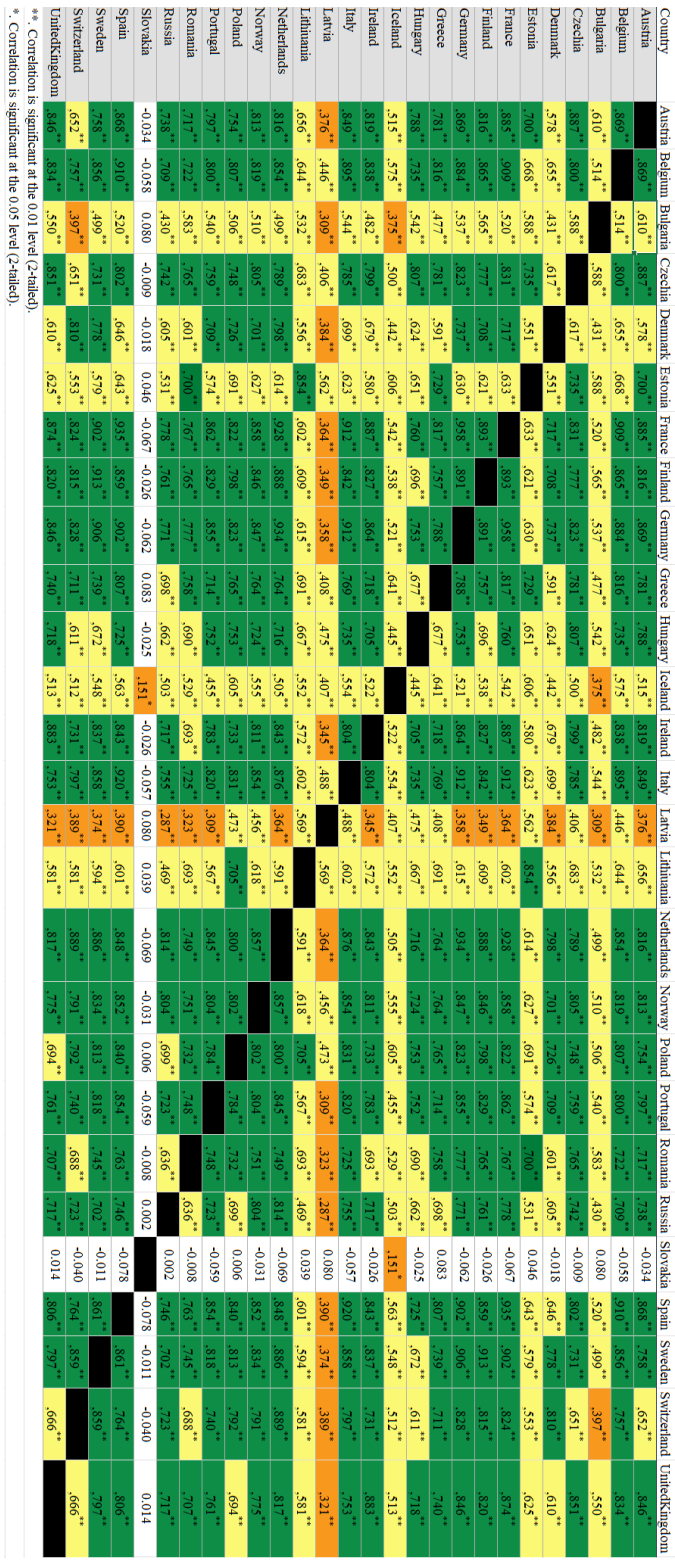
	Austria	Belgium	Bulgaria	Czechia	Denmark	Estonia	France	Finland	Germany	Greece	Hungary	Iceland	Ireland	Italy	Latvia	Lithuania	Netherlands	Norway	Poland	Portugal	Romania	Russia	Slovakia	Spain	Sweden	Switzerland	UnitedKingdom
Austria		,731**	,425**	,768**	,800**	,473**	,796**	,825**	,789**	,754**	,281**	-0,037	,699**	,817**	,289**	,438**	,797**	,777**	,670**	,696**	,617**	,680**	-0,026	,808**	,818**	,715**	,821**
Belgium	,731**		,164*	,610**	,751**	,363**	,876**	,827**	,820**	,737**	,481**	-0,046	,762**	,832**	,189**	,304**	,887**	,657**	,640**	,692**	,467**	,571**	-0,110	,802**	,806**	,773**	,786**
Bulgaria	,425**	,164*		,416**	,501**	,624**	,257**	,323**	,268**	,352**	-0,053	,215**	,260**	,334**	,545**	,640**	,262**	,414**	,317**	,363**	,565**	,450**	,299**	,302**	,295**	,314**	,340**
Czechia	,768**	,610**	,416**		,690**	,449**	,690**	,696**	,701**	,758**	,333**	,159*	,625**	,673**	,327**	,465**	,693**	,741**	,814**	,616**	,590**	,787**	-0,089	,673**	,684**	,615**	,721**
Denmark	,800**	,751**	,501**	,690**		,529**	,820**	,871**	,789**	,735**	,300**	,015	,698**	,829**	,316**	,478**	,813**	,805**	,688**	,777**	,627**	,699**	,003	,811**	,836**	,709**	,819**
Estonia	,473**	,363**	,624**	,449**	,529**		,337**	,398**	,302**	,449**	-0,106	,146*	,364**	,440**	,456**	,719**	,366**	,456**	,364**	,476**	,575**	,471**	,287**	,393**	,387**	,325**	,427**
France	,796**	,876**	,257**	,690**	,820**	,337**		,914**	,952**	,750**	,461**	-0,028	,753**	,920**	,216**	,302**	,946**	,763**	,760**	,765**	,540**	,676**	-0,121	,899**	,895**	,861**	,817**
Finland	,825**	,827**	,323**	,696**	,871**	,398**	,914**		,889**	,743**	,386**	-0,030	,766**	,875**	,258**	,356**	,897**	,788**	,718**	,788**	,561**	,685**	-0,100	,862**	,923**	,769**	,848**
Germany	,789**	,820**	,268**	,701**	,789**	,302**	,952**	,889**		,725**	,525**	-0,058	,707**	,895**	,210**	,300**	,903**	,751**	,764**	,743**	,534**	,643**	-,159*	,878**	,870**	,829**	,768**
Greece	,754**	,737**	,352**	,758**	,735**	,449**	,750**	,743**	,725**		,300*	,052	,680**	,758**	,253**	,427**	,744**	,685**	,714**	,670**	,619**	,664**	-0,015	,736**	,719**	,639**	,766**
Hungary	,281**	,491**	-0,053	,333**	,300**	-0,106	,461**	,386**	,525**	,300*		,212**	,321**	,334**	0,062	0,021	,444**	,331**	,482**	,271**	0,020	,267**	,384**	,313**	,326**	,381**	,291**
Iceland	-0,037	-0,046	,215**	,159*	0,015	,146*	-0,028	-0,030	-0,058	0,052	,212**		0,113	-0,045	0,064	0,038	0,023	0,097	,211**	-0,052	0,101	0,110	,308**	0,028	0,025	-0,039	0,080
Ireland	,699**	,762**	,260**	,625**	,698**	,364**	,753**	,766**	,707**	,680**	,321**	0,113		,724**	,264**	,345**	,770**	,591**	,645**	,621**	,446**	,545**	-0,011	,731**	,733**	,711**	,796**
Italy	,817**	,832**	,334**	,673**	,829**	,440**	,920**	,875**	,895**	,758**	,334**	-0,045	,724**		,246**	,405**	,880**	,750**	,688**	,779**	,635**	,682**	-0,091	,888**	,879**	,818**	,806**
Latvia	,289**	,189**	,545**	,327**	,316**	,456**	,216**	,258**	,210**	,253**	0,062	0,064	,264**	,246**		,648**	,219**	,300**	,193**	,226**	,364**	,431**	0,022	0,133	,184**	,225**	,218**
Lithuania	,438**	,304**	,640**	,465**	,478**	,719**	,302**	,356**	,300**	,427**	0,021	0,038	,345**	,405**	,648**		,331**	,402**	,322**	,419**	,535**	,472**	,168*	,280**	,305**	,302**	,380**
Netherlands	,797**	,887**	,262**	,693**	,813**	,366**	,946**	,897**	,903**	,744**	,444**	0,023	,770**	,880**	,219**	,331**		,790**	,746**	,729**	,529**	,661**	-0,101	,864**	,881**	,809**	,812**
Norway	,777**	,657**	,414**	,741**	,805**	,456**	,763**	,788**	,751**	,685**	,331**	0,097	,591**	,750**	,300**	,402**	,790**		,716**	,675**	,545**	,769**	-0,020	,725**	,761**	,639**	,708**
Poland	,670**	,640**	,317**	,814**	,688**	,364**	,760**	,718**	,764**	,714**	,482**	,211**	,645**	,688**	,193**	,322**	,746**	,716**		,635**	,511**	,664**	-0,115	,724**	,695**	,653**	,696**
Portugal	,696**	,692**	,363**	,616**	,777**	,476**	,765**	,788**	,743**	,670**	,271**	-0,052	,621**	,779**	,226**	,419**	,729**	,675**	,635**		,596**	,627**	-0,046	,765**	,749**	,628**	,678**
Romania	,617**	,467**	,565**	,590**	,627**	,575**	,540**	,561**	,534**	,619**	,267**	0,020	,446**	,635**	,364**	,535**	,529**	,545**	,511**	,596**		,550**	,084	,589**	,554**	,532**	,582**
Russia	,680**	,571**	,450**	,787**	,699**	,471**	,676**	,685**	,643**	,664**	,267**	0,110	,545**	,682**	,300**	,402**	,790**	,769**	,664**	,627**	,550**		-0,068	,608**	,679**	,530**	,661**
Slovakia	-0,026	-0,110	-0,089	0,003	,287**	-0,121	-0,100	-,159*	-0,015	-,384**	,308**	-0,011	-0,091	0,022	,168*	-0,101	-0,020	-0,115	-0,046	0,084	-0,068		-0,025	-0,038	-0,079	-0,024	
Spain	,808**	,802**	,302**	,673**	,811**	,393**	,899**	,862**	,878**	,736**	,313**	0,028	,731**	,888**	0,133	,280**	,864**	,725**	,724**	,765**	,589**	,608**	-0,025		,872**	,791**	,797**
Sweden	,818**	,806**	,295**	,684**	,836**	,387**	,895**	,923**	,870**	,719**	,326**	0,025	,733**	,879**	,184**	,305**	,881**	,761**	,695**	,749**	,554**	,679**	-0,038	,872**		,730**	,845**
Switzerland	,715**	,773**	,314**	,615**	,709**	,325**	,861**	,769**	,829**	,639**	,381**	-0,039	,711**	,818**	,225**	,302**	,809**	,639**	,653**	,628**	,532**	,530**	-0,079	,791**	,730**		,724**
UnitedKingdom	,821**	,786**	,340**	,721**	,819**	,427**	,817**	,848**	,768**	,766**	,291**	0,080	,796**	,806**	,218**	,380**	,812**	,708**	,696**	,678**	,582**	,661**	-0,024	,797**	,845**	,724**	

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Appendix B

Correlation coefficients for period 2.



Country	Austria	Belgium	Bulgaria	Czechia	Denmark	Estonia	France	Finland	Germany	Greece	Hungary	Iceland	Ireland	Italy	Latvia	Lithuania	Netherlands	Norway	Poland	Portugal	Romania	Russia	Slovakia	Spain	Sweden	Switzerland	UnitedKingdom
Austria		.869**	.610**	.887**	.578**	.700**	.885**	.816**	.869**	.781**	.788**	.515**	.819**	.849**	.376**	.656**	.816**	.813**	.754**	.797**	.717**	.738**	-0.034	.868**	.758**	.652**	.846**
Belgium	.869**		.514**	.800**	.655**	.668**	.909**	.865**	.884**	.816**	.735**	.575**	.838**	.895**	.446**	.644**	.854**	.819**	.807**	.800**	.722**	.709**	-0.058	.910**	.856**	.757**	.834**
Bulgaria	.610**	.514**		.588**	.431**	.588**	.520**	.565**	.537**	.477**	.542**	.375**	.482**	.544**	.309**	.532**	.499**	.510**	.506**	.540**	.583**	.430**	0.080	.520**	.499**	.397**	.550**
Czechia	.887**	.800**	.588**		.617**	.735**	.831**	.777**	.823**	.781**	.807**	.500**	.799**	.788**	.406**	.683**	.789**	.726**	.748**	.759**	.768**	.742**	-0.009	.802**	.731**	.651**	.851**
Denmark	.578**	.655**	.431**	.617**		.551**	.717**	.708**	.737**	.591**	.624**	.442**	.679**	.699**	.384**	.556**	.798**	.701**	.805**	.709**	.601**	.605**	-0.018	.646**	.778**	.810**	.610**
Estonia	.700**	.668**	.588**	.735**	.551**		.633**	.621**	.630**	.729**	.651**	.606**	.580**	.623**	.562**	.854**	.614**	.627**	.691**	.574**	.700**	.531**	0.046	.643**	.579**	.553**	.625**
France	.885**	.909**	.520**	.831**	.717**	.633**		.893**	.958**	.817**	.760**	.542**	.887**	.912**	.364**	.602**	.928**	.858**	.822**	.862**	.767**	.778**	-0.067	.935**	.902**	.824**	.874**
Finland	.816**	.865**	.565**	.777**	.708**	.621**	.893**		.891**	.757**	.696**	.538**	.827**	.842**	.349**	.609**	.888**	.846**	.798**	.829**	.765**	.761**	-0.026	.859**	.913**	.815**	.820**
Germany	.869**	.884**	.537**	.823**	.737**	.630**	.958**	.891**		.788**	.753**	.521**	.864**	.912**	.358**	.615**	.934**	.847**	.823**	.855**	.777**	.771**	-0.062	.902**	.906**	.828**	.846**
Greece	.781**	.816**	.477**	.781**	.591**	.729**	.817**	.757**	.788**		.677**	.641**	.718**	.769**	.408**	.691**	.764**	.764**	.765**	.714**	.758**	.698**	0.083	.807**	.739**	.711**	.740**
Hungary	.788**	.735**	.542**	.807**	.624**	.651**	.760**	.696**	.753**	.677**		.445**	.705**	.735**	.475**	.667**	.716**	.724**	.753**	.752**	.690**	.662**	-0.025	.725**	.672**	.611**	.718**
Iceland	.515**	.575**	.375**	.500**	.442**	.606**	.542**	.538**	.521**	.641**	.445**		.522**	.554**	.407**	.552**	.505**	.555**	.605**	.455**	.529**	.503**	.151*	.563**	.548**	.512**	.513**
Ireland	.819**	.838**	.482**	.799**	.679**	.580**	.887**	.827**	.864**	.718**	.705**	.522**		.804**	.345**	.572**	.843**	.811**	.733**	.783**	.693**	.717**	-0.026	.843**	.837**	.731**	.883**
Italy	.849**	.895**	.544**	.785**	.699**	.623**	.912**	.842**	.912**	.769**	.735**	.554**	.804**		.488**	.602**	.876**	.854**	.831**	.820**	.725**	.755**	-0.057	.920**	.858**	.797**	.753**
Latvia	.376**	.446**	.309**	.406**	.384**	.562**	.364**	.349**	.358**	.408**	.475**	.407**	.345**	.488**		.569**	.364**	.456**	.473**	.309**	.323**	.287**	0.080	.390**	.374**	.389**	.321**
Lithuania	.656**	.644**	.532**	.683**	.556**	.854**	.602**	.609**	.615**	.691**	.667**	.552**	.572**	.602**	.569**		.591**	.618**	.705**	.567**	.693**	.469**	0.039	.601**	.581**	.581**	.581**
Netherlands	.816**	.854**	.499**	.789**	.798**	.614**	.928**	.888**	.934**	.764**	.716**	.505**	.843**	.876**	.364**	.591**		.857**	.800**	.845**	.749**	.814**	-0.069	.848**	.886**	.889**	.817**
Norway	.813**	.819**	.510**	.805**	.701**	.627**	.858**	.846**	.847**	.764**	.724**	.555**	.811**	.854**	.456**	.618**	.857**		.802**	.804**	.751**	.804**	-0.031	.852**	.834**	.791**	.775**
Poland	.754**	.807**	.506**	.748**	.726**	.691**	.822**	.798**	.823**	.765**	.753**	.605**	.733**	.831**	.473**	.705**	.800**	.802**		.784**	.732**	.699**	0.006	.840**	.813**	.792**	.694**
Portugal	.797**	.800**	.540**	.759**	.709**	.574**	.862**	.829**	.855**	.714**	.752**	.455**	.783**	.820**	.309**	.567**	.845**	.804**	.784**		.748**	.723**	-0.059	.854**	.818**	.740**	.761**
Romania	.717**	.722**	.583**	.765**	.601**	.700**	.767**	.765**	.777**	.758**	.690**	.529**	.693**	.725**	.323**	.693**	.749**	.751**	.732**	.748**		.636**	-0.008	.763**	.745**	.688**	.707**
Russia	.738**	.709**	.430**	.742**	.605**	.531**	.778**	.761**	.771**	.698**	.662**	.503**	.717**	.755**	.287**	.469**	.814**	.804**	.699**	.723**	.636**		0.002	.746**	.702**	.723**	.717**
Slovakia	-0.034	-0.058	0.080	-0.009	-0.018	0.046	-0.067	-0.026	-0.062	0.083	-0.025	.151*	-0.026	-0.057	0.080	0.039	-0.069	-0.031	0.006	-0.059	-0.008	0.002		-0.078	-0.011	0.046	0.014
Spain	.868**	.910**	.520**	.802**	.646**	.643**	.935**	.859**	.902**	.807**	.725**	.563**	.843**	.920**	.390**	.601**	.848**	.852**	.840**	.854**	.763**	.746**	-0.078		.861**	.643**	.806**
Sweden	.758**	.856**	.499**	.731**	.778**	.579**	.902**	.913**	.906**	.739**	.672**	.548**	.837**	.858**	.374**	.594**	.886**	.834**	.813**	.818**	.745**	.702**	-0.011	.861**		.579**	.797**
Switzerland	.652**	.757**	.397**	.651**	.810**	.553**	.824**	.815**	.828**	.711**	.611**	.512**	.731**	.797**	.389**	.581**	.889**	.791**	.792**	.740**	.688**	.723**	-0.040	.764**	.859**		.666**
UnitedKingdom	.846**	.834**	.550**	.851**	.610**	.625**	.874**	.820**	.846**	.740**	.718**	.513**	.883**	.753**	.321**	.581**	.817**	.775**	.694**	.761**	.707**	.717**	0.014	.806**	.797**	.666**	

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Resümee

Euroopa aktsiaturgude koosliikumine kriisi perioodidel: 2007– 2008 ja 2020 –2021 perioodide võrdlus

Sten Alexander Tolgu

Kirjanduse ülevaade näitas seda, et aktsiaturgude integratsiooni võib mõista kui riikide aktsiaturgude omavahelist seotust, mis põhineb makromajanduslikel teguritel, nagu väliskapitali vood, sama valuuta kasutamine, sama intressimäär, välismaiste otseinvesteeringute määr ning sarnane raha- ja fiskaalpoliitika. Aktsiaturgude koosliikumine saab kõige paremini defineerida kui korrelatsiooni ja seda võib mõista kui integratsiooni indikaatorit, kuna varasemad uuringud on näidanud, et integreeritumad majandused näitavad aktsiaturgudel suuremat koosliikumist. Kirjanduses on rõhutatud ka riskide hajutamise potentsiaali, mis eksisteerib aktsiaturgudel, mis näitavad kõrget ainulaadset hinnaliikumist, võrreldes riikidega, mille aktsiaturud näitavad vastupidist.

Sarnased varasemad empiirilised uuringud on näidanud trendi, mille kohaselt euroopa vähem arenenud riikide aktsiaturgudel on kriisi- ja karutsükliperioodidel madal koosliikumine võrreldes euroopa rohkem arenenud riikide aktsiaturgudega. Arvestades, et aktsiaturgude integreerumine sõltub makromajanduslikest teguritest, võib koosliikumise madalat taset seletada väiksema makromajandusliku seotusega teiste riikide majandusega. Praktiline rakendus seisneb selles, et riigid, mille aktsiaturud näitavad vähem koosliikumist teiste turgudega, pakuvad investoritele kriisi ajal võimalusi portfelli hajutamiseks ja riskijuhtimiseks.

Empiirilises osas kasutati päevatootluse arvutamiseks aktsiaindeksite päevaseid sulgemishindu. Päevaseid tootluseid kasutati seejärel 27 Euroopa riigi paaripõhise korrelatsioonikoefitsientide arvutamiseks 2007-2009 ülemaailmse finantskriisi ja Covid-19 pandeemia ajal. Vajadusel konverteeriti päeva sulgemishinnad eurodesse. Empiirilise uuringu peamised tulemused on järgmised:

- Enamik Euroopa aktsiaturge on positiivses korrelatsioonis.
- Perioodi 2-s oli suurem osa aktsiaturgudest tugevamalt positiivses korrelatsioonis kui periood 1-s.
- Majanduslikult arenenud euroopa riikide aktsiaturud on peaaegu täiuslikus positiivses korrelatsioonis.

- Majanduslikult vähem arenenud euroopa riikidel oli suurem osa korrelatsiooni koefitsiendid nõrgas ja keskmises positiivses vahemikus, mis viitab ainulaadsemale hinnaliikumisele kriiside ajal.

Kokkuvõtteks võib öelda, et akadeemilise kirjanduse läbivaatamise, andmete kogumise ja kvantitatiivse analüüsi abil on saavutatud eesmärk hinnata euroopa turgude koosliikumist kahe erineva kriisiperioodi jooksul. Empiiriline uuring täiendas olemasolevat kirjandust, hõlmates nii EL-i kui ka mitte-ELi Euroopa riike ning hinnates ühe perioodi asemel kahte perioodi. Töö eesmärk on samuti saavutatud, kuna investorid saavad tutvuda esitatud korrelatsiooniandmetega, et leida turge, millel on nõrgem koosliikumine oma kodumaa turuga, et teha kindlaks võimalikud võimalused portfelli hajutamiseks.

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