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"To what extent are stock returns driven by mean and volatility spillover effects"?

Evidence from eight European stock markets

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Abstract

The paper investigates the mean and volatility spillover effects from U.S and EU stock markets as well as oil price market into national stock markets of eight European countries. The study finds strong indication of volatility spillover effects from global US, regional EU, and world factor oil towards individual stock markets. While both mean and volatility spillover transmissions from the U.S are found to be significant, E.U mean spillover effects are negligible. To evaluate the volatility spillovers, the variance ratios are computed and the results draw to attention that the individual emerging countries' stock returns are mostly influenced by the U.S volatility spillovers rather than the EU or oil markets. Additionally, examination of only global and regional stock markets spillover transmissions into European stock markets also confirms the dominating presence of U.S spillover transmissions. Furthermore, I also implement asymmetric tests on stock returns of eight markets. Some evidences of asymmetric effects are reported. In particular, the stock markets of Hungary, Poland, Russia and Ukraine are found to respond asymmetrically to negative and positive shocks in the U.S stock returns. The weak evidence of asymmetric effects with respect to oil market shocks is found only in the case of Russia and the quantified variance ratios indicate that presence of oil market shocks are relatively higher for Russia. Moreover, a model with dummy variable confirms the effect of European Union enlargement on stock returns only for Romania. Finally, a conditional model suggests that the spillover effects are partially explained by instrumental macroeconomic variables, out of which exchange rate fluctuations play a key role in explaining the spillover parameters rather than total trade to GDP ratios in most investigated countries.

Key words: Stock markets, the U.S, E.U, volatility spillovers, emerging markets, mean, oil price, exchange rates, asymmetric effects.

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1. Introduction

1.1 Background

Over the last decades, financial markets have experienced dramatic expansion and interaction with one another. Higher liberalization of economies, globalization and interrelated synchronization of financial markets have influenced the bilateral movements of equity markets. As the result of globalization and integration and growing technological advances in financial markets, the innovations and shocks in dominant equity as well as commodity markets are very likely to influence the stock returns of emerging markets. Especially for investors, the behavior and sources of market volatility have paramount importance for realization of hedging strategies and international asset diversification decisions on global financial markets. Additionally, the diversifications of portfolios of assets are also subject to interlinkages among capital markets. Hence, the understanding and investigation of this phenomenon is also very crucial for policy makers.

On the other hand, the interrelated development of stock markets across developed and developing countries have created good opportunities for international investors to invest in stock markets of emerging economies. Needless to say, the financial markets of the emerging and developing economies have different characteristics compared to those of developed countries. For instance, an empirical study by Bekaert and Harvey (1995), on highly emerging markets using data of International Finance Corporation (IFC) , finds that emerging markets are characterized by relatively high returns and low correlation compared to advanced markets. Emerging stock markets seem to be very appealing investments since they provide higher expected. Apart from higher sample expected returns, distinguishing characteristics of emerging markets, among other things, are recognized relatively low correlations with mature capital markets and higher volatility (Harvey 1995). Thus, these differences make a an empirical investigation of emerging stock markets very appealing, and it is interesting and valuable to examine stock returns of European emerging and developing markets within a mean and volatility spillovers framework.

Taking into consideration aforementioned implications, the paper intends to examine the mean and return spillover effects from regional, global, and world factor into eight individual national stock exchange markets of European countries. More specifically, the empirical study will analyze the possible evidence of mean and volatility transmissions from the global

US and the regional EMU[1] stock markets. It is obviously feasible that there are other factors besides the regional and global stock markets that propel the stock returns in emerging equity markets. It is also broadly recognized that national stock markets are also influenced by world oil price innovations[2]. This information also plays a key role in explaining variations and stock returns in emerging European markets. Consequently, alongside with spillover effects from stock markets, with introduction of the oil price shocks the paper claims as a world factor. Rising oil prices and shocks driven by oil price tend to be another source of spillover effects which might deter the individual European emerging and developing stock markets.

1.2 Purpose and contribution of the thesis

The purpose of this thesis is to examine the mean and volatility spillovers effects from a global factor US (GF US)[3] stock market, regional factor Europe (RF EU) stock market and as the world factor oil price (WF Oil) changes on the eight European emerging and developing countries from September 2000 until March 2012. The countries examined are: Croatia, Czech Republic, Hungary, Poland, Romania, Russia, Turkey, and Ukraine. The mean and volatility spillover effects across financial markets are explored by applying the GJR-GARCH model introduced by Glosten, Jagannathan and Runkle in 1993. Eventually, the calculated variance ratios will allow us to quantitatively analyze the proportion of volatility spillovers from various sources. Additionally, by excluding the oil spillover effects the paper also examines the size and effect of spillover effects only from two markets: Europe and the US.

The statement and its empirical implication whether stock markets are influenced by financial crises and extreme events is recognized one of the major concerns in empirical finance. The most evident examples for stock market "turmoil" are Asian crisis in 1997, Russian Bond default in August 1998 and the recent Global Financial Crisis of 2008. For instance, it can also be observed that all the stock indexes and returns experienced sudden jumps prior to recent Global Financial Crisis of 2008 (Appendix: Figure A1). Thus, in order to shed more light on the idea whether spillovers towards stock markets increase or decrease prior to extreme events, the paper will explore the spillover effects in two sub-periods. The mean and volatility spillovers effects on stock markets are examined before and aftermath of Global

[1] The EMU index is defiend as "regional EU" effect.

[2] Note: The oil price is defined as a world factor taking into account its high importance for entire economic activates across the World countries.

[3] Throughout the paper the terms "Global Factor US", "Regional Factor EU" as well as "World Factor Oil" are respectively coined with "GF US", "RF EU" and "WF OIL"

Financial Crisis of 2008. Although the spillovers models are explored by using the GJR-GARCH model, the asymmetric tests on stock returns of individual countries will aid for a more comprehensive investigation of asymmetric existence with respect to each spillover intensities. Additionally, the paper includes oil price shocks as a world factor to examine possible spillover effects on stock returns. Moreover, the thesis applies macroeconomic information instruments through conditional spillover model. The approach introduced by Ng (2002) allows exploring the spillover parameters on constant model for national stock markets.

Furthermore, the sensitivity analysis and EU enlargement effect from this study aim to respectively, contribute an estimation framework and useful information about future expectations for investors investing in Croatian and other EU candidate stock markets. Questioning whether new accession to European Union (EU) increases or decreases volatility, the study introduces an AR-GARCH dummy variable model for Czech Republic, Poland, Hungary and Romania stock markets. Using dummy analysis seems to be a good proxy for future expectations regarding stock markets returns for Croatia and other countries that are considered as potential candidates for the EU in coming years.

The paper contributes to empirical literature in several ways. The paper, first and foremost, targets the investigation of European emerging and developing economies, since several other papers explore the developed European Monitory Union (EMU) as well as single economies (e.g., Christiansen 2004, Baele, 2005, Babetskii et al., 2007. e.g., Chelley-Steeley, 2005). To my knowledge, it is the first paper that includes the broad and extensive analysis of eight European national stock markets which in addition to being developing economies are not European Monetary Union (EMU) members. In addition, my paper examines the mean and volatility spillover from oil shocks to each country's stock returns, too. Moreover, the EU enlargement effect and so-called sensitivity analysis are explored in this study. From a methodology viewpoint, it then explores the constant and conditional AR (1)-GJR-GARCH (1.1) model and uses additional asymmetric tests that add value to possible asymmetric analysis in emerging market empirical literature.

1.3 Research questions

This study aims to address the following research questions;

1. How do mean and volatility spillover effects of from the US, the EU and the oil market, as a world factor, drive stock returns in European emerging and developing markets?
2. Which spillover effect has the possibility of having highest magnitude effect on the selected eight national European stock markets?
3. Does the EU enlargement matter for spillover effects on stock returns?
4. How well are the macroeconomic instruments able to explain global US and regional EU spillover effects?

1.4 Limitations

In this paper, I examine the mean and volatility spillover effects for eight European countries, however, the study can be extended for examination of other countries, depending on availability of sample data. Furthermore, I focus only on three sources of spillover effects, however there are other possible external or cross country spillover effects amongst investigated national stock markets.

Despite the fact that multivariate GARCH estimation using a VEC and a BEKK approach gives a much broader analysis than the univariate models, it also imposes some restrictions and increases the number of unknown parameters (Brooks, 2003). In addition, the VEC and BEEK M-GARCH models are rarely used for more than 3 or 4 asset series (Bauwens, Laurent and Ronbouts 2006). This is due to the fact that whenever the number of asset series explored in the M-GARCH model increases, the estimation of the model sharply gets impossible. For example, in the case of two asset series, the time varying variance and covariance equations for the unrestricted VEC model contain 21 parameters (Brooks, 2008). Thus, investigation of eight markets through a M-GARCH framework would have utmost increase the number of unknown parameters in this study.

1.5 Outline

The second section of the thesis starts of with an in depth coverage of the literature giving a background of the importance of studying spillover effects from financial and energy markets and with a particular focus on emerging markets. Next, an overview of individual stock markets follows. This section provides the market characteristics of investigated emerging European markets. In the fourth section, data analysis provides the use of the employed data and preliminary analysis. Then the econometric methodology is presented in section five. Section six presents the empirical results. Finally, section seven concludes the thesis.

2. Review of empirical research

This section aims to explore the issues and previous research on mean and return spillover effects. By doing this, it will show the overview of previous empirical studies and the gap in the area of return and volatility spillover analysis for Emerging markets. The section will then conclude by reiterating the research questions that aim to fill a gap in under-researched stock exchange markets that are crucial in the area of financial market interdependences in empirical finance.

2.1 Overview of spillover effects

There is vast literature investigating and analyzing the volatility and mean spillovers that explores mainly the stock and bond markets of the developed financial markets. For instance, Engle, Ito and Lin (1990) who are one of the pioneers of the spillover phenomenon examination applying GARCH type family models, for instance, found evidence of intra-day volatility spillovers by investigating the US and Japanese foreign exchange markets. A similar result regarding strong spillover effects between the US, the UK and Japanese for stock return markets is observed in empirical study by Hamao, Masulis, and Ng (1990) through multivariate GARCH model (1,1).

Furthermore, Ng (2000) finds that the world factor US and regional factor Japan induce significant volatility spillovers to stock returns of Asian pacific-basin region. By applying similar model, Miyakoshi (2002) also finds that Japanese stock market is also adversely influenced by Asian Pacific-Basin countries. Moreover, Christiansen (2007) finds that volatility in bond markets is highly influenced by regional factors for European Monetary Union (EMU) countries. In contrast, in the case of non-EMU countries the volatility spillover driven by local and global US spillover effects tend to be much larger and stronger those compared to regional European effects.

The study by Baele (2005) investigates conditional volatility spillovers relying on regime switching models from the US and aggregate EU stock returns to thirteen individual Western European developed markets, respectively for the period of second half 1980s and first half of 1990s. The author reported statistically and economically significant spillover intensities from the US and EU markets and besides that the magnitude of spillover effects increased dramatically from 1980s to 1990s. Despite the fact that increase for the EU shocks is more than the US shocks from second half to first half of 1990s, the individual countries stock markets are explained more by the US global spillover effects compared to regional European effects, which are respectively 27% and 23% of total variances.

Thus, aforementioned major impressive studies demonstrate that the conditional second moments of the distribution of the returns, in other words, volatility spillovers have been extensively explored and analyzed in developed European as and developing Asian countries. However, the spillover intensities need to be explored for the emerging and developing stock markets of emerging, in particular European countries.

2.2 Volatility and mean spillovers in Emerging markets

During last decade new literatures also attempt to explain spillovers effects for developing and emerging markets. One of the pioneer papers in this field investigating the volatility spillover effects of twenty world emerging markets is studied by Bekaert and Harvey (1997). They find that global factors drive more volatility effects in the fully integrated markets, however, in the segmented markets volatility seems to be caused mostly by local factors. Their study also draws an attention that although volatility appears to be different in various emerging markets, the more liberalized open economies tend to possess lower volatiles and capital market liberalization process is the one of the pronounced driving factor in significant decrease in volatilities.

Furthermore, Rockinger and Urga (2001) explore the effects from London and Frankfurt stock exchange markets to Central European stock markets over 1994-1997 periods. Applying similar method proposed by Bekaert and Harvey (1997), they revealed that although both markets drive significant volatility spillover effects, the effects from UK stock market tends to be more substantial than German stock markets. Other research by Scheicher (2001) investigates the stock markets of Central and Eastern European (CEE) countries, namely, Czech, Hungary, and Poland in the light of regional and global financial market interdependences. Author's study concludes that equity markets are influenced by regional and global spillover effects. In contrary the volatility spillovers seem to be driven mostly by regional factors.

On the other hand, Gilmore and McManus (2002) examine the short and long run integration and bilateral relationships between the US and individual CEE stock markets, and find that indication of possible interaction is negligible. Applying cointegration tests the empirical study by Égert and Koubaa (2004) based on GARCH model indicates that CEE countries are characterized higher volatility and more asymmetry than G-7 countries. Moreover, the interactions between three CEE states and developed markets such as Germany and the US are explored by Syriopoulos (2007). The author finds long run interactions between developed countries and CEE states. Contrary, in the short run US stock market returns impose more dominant effects than the one from Germany.

Other research study by Kasman and Torun (2008) investigates the presence of dual long memory approach proposed by Teyssiere (1997). Their findings show significant evidence of long memory in time varying variance and mean for CEE stock markets applying fractionally integrated autoregressive GARCH model. Kocenda and Hanousek (2010) use highly frequent intraday data to examine spillovers and macroeconomic news effects from global factor US and regional factor Germany into Czech, Hungary, and Poland. The authors consider the Frankfurt stock exchange as a regional factor. They find that although both of the markets drive strong volatility spillover transmissions, spillover effects induced by regional Frankfurt Stock is higher than the New York stock exchange market. However, announcement affects caused by macroeconomic news do not present clear cut findings and in fact those effects from the US market are almost negligible. Along the way, one of the extensive empirical studies introduced by Beine, Caporale, and Spagnolo (2010), investigate the equity markets of 41 developing countries across the world and find that in most of the countries equity returns are influenced regional and global spillover effects. Using multivariate VAR-GARCH (1, 1) model authors also conclude that Asian and Latin America countries are more exposed both to return and volatility spillovers, while in emerging European countries volatility spillovers are main statistical driven stock markets In addition, if the global spillover effects are dominating in emerging Asian financial markets, regional spillovers are appeared to be more pronounced in Latin America and developing European countries.

Last but not least, Gilmoure et. al., (2006), analyses the co movements of CEE and developed EU stock market returns. Relying on static and dynamic methods, they report that co-movements between financial markets have not been much altered after EU membership. On the other hand, the behavior of stock returns of “new” EU member countries have been explored Dvořák and Podpiera (2006), where the authors conclude that some Baltic and CEE countries’ accession to EU is followed by higher stock market returns. The similar results are observed earlier studies for different markets by Henry (2000), Bekaert and Harvey (2000). Common result is that stock market indexes have been significantly increased in response to financial market integration.

In summary, we have seen that most empirical studies have focused on developed markets both across the World and in Europe. After EU enlargement process some more new empirical studies have been studied on Central and Eastern European countries (CEECs) in recent years. Still, the empirical examination of stock markets of other emerging countries such as, Croatia, Russia, Ukraine and Turkey are under-researched which needs to be further investigated as well as more deeper analysis (e.g. Multivariate analysis) are still under research.

2.3 Literature on oil shocks impact on equity markets

It is undeniable fact that the oil price movements and its shocks have paramount importance for all the countries in world. Taking its effect on economy, the studies of oil price effects in economy are firstly introduced by Hamilton (1983) and afterwards substantial numbers of empirical studies have been studied. Gisser and Goodwin (1986) and Hickman et al. (1987), for instance, find that relationship between oil prices changes and economic activity characterize negative relationship. Apergis and Miller (2009) examine G-7 and plus Australia’s stock market returns and they argue that stock markets are influenced by oil price shocks via future earnings. In other words, sudden increase in oil price, ceteris paribus, can yield production process to be more expensive, and subsequently lowers final output and affecting negatively reduce expected earnings.

Along the way, other empirical work by Mork et. al., (1989), Jimenez-Rodriguez and Sanchez (2005) and Farzanegan and Markwardt (2009) shed more light on asymmetric effect of stock returns towards in oil price changes. The examination is motivated by the notion that stock returns and economic activity are highly influenced by negative impact of oil price increases rather than the positive impact of oil price decreases. Thus, being the crucial commodity in almost any kind of industry the oil price shocks' towards macro economy and equity markets by have been widely explored. The effect of oil price shocks and spillover effects into stock market returns will be briefly summarized in following paragraphs. Moreover, Sadorsky (1999) studies the oil prices changes and equity returns for the US stock market relying on a VAR model approach. The author reports that stock returns have been significantly and negatively affected by oil price shocks. Further, Basher and Sadorsky (2006) examine similar analysis on stock markets of emerging oil importing countries for period 1992–2005, and their conclusion draws an attention that the negative and significant evidence of oil price changes for all countries.

There are also abundant empirical studies analyzing oil price effects by oil price shocks in European economies. For example, Lardic and Mignon (2006) revealed the significant oil price impact on GDP as well as asymmetric cointegration relation for 12 European developed countries over 1970-2003. On the other hand, significant oil price volatility spillover for the U.S. and 13 European countries' stock markets has been reported by Park and Ratti (2008). However, asymmetric existences towards oil price shocks tend to demonstrate no evidence for oil importing European economies. In addition, applying VECM model, some OECD countries equity markets have been explored by Miller and Ratti (2009) and the strong evidences are found for Germany, Italy, the UK and the US which imply price positive oil shocks (price decrease) tend to boost stock prices on the short run. However, the results are statistically insignificant for the long period. Moreover, empirical evidence through VAR model over period January 1999 -September 2009 on Brazil, China, India and Russia by Ono (2009) finds existence of strong asymmetric effects. The study also indicates that oil prices shocks drive significant impacts on stock returns for all three countries, except for Brazil.

Thus taking into consideration aforementioned literatures it can be shortly summarized that, the oil price shocks have caused mainly significant negative impact on overall macroeconomic activity and the stock markets of various investigated countries. Secondly, oil price movements seem to be characterized by asymmetric effect. Third, from literature coverage viewpoint most of previous studies on spillover effects from oil shocks broadly study the case of developed countries. Relatively, interactions between oil prices and stock markets are not widely studies for developing European countries that need to be conduct relevant investigations.

It is worthwhile to mention that from the literature reviews first there is a lack of knowledge of the mean and volatility spillover effect for European emerging and developing stock markets, which the thesis aims to fill. In addition, the spillover effects from oil returns will be explored along with the U.S and EU factors. In order to do this, the paper examines the research questions noted in the Introduction. First, how well the stock returns of eight national countries are driven by mean and volatility spillovers from the US, the EU and the Oil market?; Second, which of the spillover sources account for most of the shocks in total each country's unexpected returns?; Then, third question follows that are the macroeconomic instrumental variables able to explain the mean and volatility spillovers from global US and regional EU market?; Finally, the answering question whether EU enlargement effect for spillover effects is another of interest of imperial study.

3. Overview of national stock markets of European countries

The paper investigates the national stock markets of eight European countries. The most of these countries of Europe are rapidly growing emerging and developing countries. Table 1 presents the all the stock exchanges indexes employed in this empirical study.

Table 1: Stock market indexes

Country/market[4]:	Index name	Currency
Croatia	CROBEX	Kuna
Czech	PX	Koruna
Hungary	BUX	Forint
Poland	WSE 20	Zloty
Romania	BET	Lei
Russia	MICEX	Rouble
Ukraine	PFTS SE	Hryvnia
Turkey	ISE 100	Lira
EU (EMU)[5]	MSCI EU	Euro
USA	S&P 500	US Dollar

According to International Finance Corporation (IFC), amongst the investigated countries, Czech, Hungary, Poland, Turkey, and Russia are classified as emerging European stock markets. It should be mentioned that the economic liberalization and economic reforms especially in these emerging markets over the last decade enabled them to attract foreign direct investments and achieve robust economic growth rates (Appendix A1). Relatively, the

[4]Hence the name of the country is denoted and appeared in tables as following; Croatia (CRO), Czech (CZE), Hungary (HUN), Poland (POL), Romania (ROM), Russia (RUS), Turkey (TUR) and Ukraine (UKR).

[5] EMU denotes the European Monetary Union and purely is consists of only EMU member countries. In the rest part of the paper I will use EU which is referred to EMU.

stock markets of other investigated countries, such as Croatia, Romania, and Ukraine are being considered developing equity markets. In the following paragraphs the brief overview about each national European stock exchange will be presented. Additionally, the primary financial indicators of stock exchange markets, such as market capitalization, trading volume, the number of listed firms and CAP/GDP ratio are summarized in Table 2 for each country.

European emerging stock markets: Czech Republic: Prague Stock Exchange (PSE)

The modern Prague Stock Exchange (PSE) was established and developed after the collapse of Communism System in 1993. Nowadays, known as PX 20 Stock Exchange, it is the largest financial markets of securities in the Czech Republic.[6] After being member of European Union (EU) in 2004, sequential improvements are achieved. Essentially, in May of 2004 it became the member of Federation of the European Securities Exchanges and the Stock Exchange was granted "designated offshore securities market" by U.S. Securities and Exchange Commission (the U.S. SEC). Finally, as reported in Table 2, it is second largest Stock Exchange among CEE countries.

Hungary: Budapest Stock Exchange (BSE-BUX)

Similar to other CEE countries the reopening of Budapest Stock exchange was realized in the beginning of 1990s. The first pronounced development was achieved through allowing all the trading activities to be realized electronically, instead being made physically until 1999. As the matter of fact, The BUX is considered relatively less emerged among the CEE states (Table 2).[7] Keystone success of the BSE starts with change in ownership structure in 2004, where Austrian banks became the largest owners of BSE and from that period securities market in Hungary paved new successful direction. Later in 2005, merger of BSE with Budapest Commodity Exchange also contributed to the number of activities in BSE.

Poland: The Warsaw Stock Exchange (WSE)

The contemporary and market oriented stock exchange market in Poland, known as The Warsaw Stock Exchange (WSE) joint-stock company was established on April, 1992[8]. The development of WSE was also quickly boosted when Poland became the member of EU in 2004 and it also allowed economy quickly to be liberalized. As the result, the WSE became the largest securities market among CEE countries (Table 2). In addition, the WSE is

[6] http://www.pse.cz/Statistika/Burzovni-Indexy/
[7] http://www.bse.hu/topmenu/about_us/financialreports
[8] http://www.gpw.pl/dane_rynkowe_en

considered as European most dynamic IPO market in recent years. During the short period of time WSE made successful developments as an emerging stock market. For instance, in early years of existence WSE established trading of derivatives and it launched so called WARSET cooperative trading system with Paris Stock Exchange and “Master Agreement” with NYSE respectively in 2000 and 2007. Essentially, in order to increase the number of market participants and develop the entire securities market the exchangeable regulated market and bond market were launched in 2007.

Russia: MICEX Stock Exchange Market

There are two major stock exchange indexes, namely RTS and MICEX in Russia. Computed since 1997, the MICEX index is the largest stock exchange in Russian market as well as among all the investigated stock markets in this study. Being covered over 80% of Russia’s exchange share market, and thereby including 30 most liquid and highly developing companies, it is recognized much broader index than RTS index. Moreover, Oil and Gas sector account around 44% of trading volume of MICEX index and this shows the importance of oil & gas sector in Russia’s stock market (MICEX, 2012). Additionally, MICEX index is considered world’s 30 top stock exchanges across all the international financial markets[9] (Table 2). On average 1300 securities are daily traded in MICEX, where 54% of them are Russian based issued securities. Finally, the index was recorded as fourth top performing broad market index for Europe - Africa - Middle East region during 2010[10].

Turkey: Istanbul Stock Exchange (ISE)[11]

Istanbul Stock Exchange (ISE) is recognized as the single stock exchange in economy of Turkey. Despite the fact that it was launched only weekly based in 1985, the index has been calculated daily base since 1987.Including indexes such as ISE National 50 and ISE National 30 Index the main ISE national 100 has served the for main individual and institutional investors. In addition, one of the subtle developments was made by Governmental Decree in August 1989 which allowed international investors to participate all kind of security trade activities in ISE 100. Last but not least, the trading sessions were prolonged and implemented in two sessions, respectively from 10:00-12:00 and between 14:00-16:00. Essentially, these kinds of improvements contributed to performance and development of security market in

[9] MICEX Stock Exchange, at: <http://www.micex.com/group/fbmmvb/profile>
[10] World Federation of Exchanges (WFE), 2010 “Annual reports and Statistics”, pp. 40
[11] http://www.ise.org/AboutUs/AboutUsMain.aspx

Turkey. Ultimately, being known as highly growing emerging markets 2010, the ISE National 100 index was also recognized as one of the highly performance security market index in Europe - Middle East region[12]. The market characteristic of ISE is reported in Table 2.

European developing stock markets: Romania: Bucharest Stock Exchange (BSE-BET)

Bucharest Stock Exchange (BSE) market is the only stock exchange market in Romania. It was legally established in 1994, and started to properly function in the fourth quarter of 1995 year. It has experienced successful development story since 2006 (e.g. membership to World Federation of Exchanges, (WFE). Similarly to CEE countries, when Romania became full membership to EU and its financial markets also developed since ever. Despite the fact that, the BET Index as well as Romanian economy has experienced rapid fluctuations during the first years of membership, eventually the new international investors started to invest in BSE market, which in turn allowed developing securities markets in Romania, since 2007[13].

Croatia: Zagreb Stock Exchange (ZSE)

Zagreb Stock Exchange (ZSE) market is established in 1991 and it can be considered as one of the developing equity market among all the examined stock exchange markets. In the recent years development Zagreb Stock Exchange Academy played a key role for development of the securities markets. It is also implementing joined development training programs with Madrid Stock Exchange.[14] The primary market indicators of the stock exchange are summarized in Table 2.

Ukraine: Ukraine Stock Exchange Market

The Ukrainian Stock Exchange (USE) was established in 1991.[15] It has been characterized as centralized securities market and yet has been considered with a plenty of distribution, redistribution as well as post privatization activities. Although, security market is considered as development some downsides such as, various trading systems create some problems in terms of liquidity and transparency. Nowadays, the stock exchange includes around 52 members ranging from financial to energy companies. The recent developments, financial and other market features of stock exchange are presented in Table 2.

[12] World Federation of Exchanges (WFE), 2010 “Annual reports and Statistics”, pp. 40
[13] http://www.bvb.ro/NewsandServices/DataVendors.aspx
[14] http://zse.hr/default.aspx?id=32900
[15] http://www.pfts.com/en/trade-information/

Table 2: Annual financial characteristics of national stock markets of European countries, 2004-2011

	2004	2005	2006	2007	2008	2009	2010	2011
Croatia								
Capitalization (US$ m)	7,785	8,787	18,969	10,711	13,430	10,315	11,272	12,900
CAP/GDP Ratio	27.1	29.2	59.1	12.0	39.0	32.5	35.4	41.4
Trading vol. (US$ m)	349	545	1,196	2,336	1,708	1,902	2,351	2,549
Number of companies	145	145	183	353	376	381	382	390
Czech Republic								
Capitalization (US$ m)	43,670	51,124	76,259	101,772	57,806	70,256	73,075	53,198
CAP/GDP Ratio	47.87	49.36	65.12	82.84	38.06	52.72	52,9	35,85
Trading Vol. (US$ m)	26,841	22,382	26,382	25,231	37,457	30,762	27,677	35,184
Number of companies	35	40	45	46	44	44	43	41
Hungary								
Capitalization (US$ m)	28,630	32,575	41,784	46,165	18,465	30,036	27,708	30,008
CAP/GDP Ratio	34.2	36.7	52.0	49.5	19.0	38.5	36.5	36.14
Trading vol. (US$ m)	13,369	24,151	30,909	47,586	30,706	25,375	26,263	29,874
Number of companies	47	44	41	41	43	46	52	53
Poland								
Capitalization (US$ m)	71,547	93,602	148,775	211,620	90,815	150,961	190,215	188,594
CAP/GDP Ratio	36.5	39.6	58.1	70.3	24.6	52.4	56.6	51.0
Trading vol. (US$ m)	16,269	30,421	56,372	87,962	69,499	53,509	69,157	69,496
Number of companies	230	242	265	375	458	496	584	461
Romania								
Capitalization (US$ m)	4,004	6,218	8,635	10,951	3,923	4,949	5,495	6,121
CAP/GDP Ratio	16.2	21.4	27.5	27.6	10.4	17.1	20.0	21.6
Trading vol. (US$ m)	313	1,019	1,110	1,869	2,100	2,845	3,014	2,842
Number of companies	3747	2478	2096	1824	3802	3784	3789	3810
Russia								
Capitalization (US$ m)	486,630	477,609	480,024	456,570	337,088	736,306	949,148	984,411
CAP/GDP Ratio	45.0	41.2	36.1	30.1	19,15	60,39	75,15	74.2
Trading vol. (US$ m)	357,800	411,000	422,874	357,457	448,874	433,811	407,579	449,544
Number of companies	220	222	224	230	233	234	245	251
Turkey								
Capitalization (US$ m)	74,993	161,532	162,398	286,571	118,328	233,996	307,715	318,477
CAP/GDP Ratio	25.3	33.7	31.6	44.4	16.3	22.3	24.1	30.9
Trading vol. (US$ m)	113,989	201,318	222,724	294,295	247,893	301,122	410,608	427,798
Number of companies	296	302	316	319	315	315	339	342
Ukraine								
Capitalization (US$ m)	296 397	345 794	411 122	599 831	528 385	470 796	565 708	611 835
CAP/GDP Ratio	2.6	2.8	3,1	4.2	5.5	6.0	6.9	5.9
Trading vol. (US$ m)	15 470	18 000	19 972	21 456	22 560	24 315	25 003	111 721
Number of companies	55	56	56	60	64	65	67	68

Source: World Development Indicators (WDI) and World Federation of Exchanges (WFE-2008-2011).
Note: CAP/GDP is ratio of total market capitalization to GDP and is presented in %. The listed companies are only domestic companies.

4. Data and Preliminary Analysis

The following section aims to clarify the data employed in this paper. The section also presents the preliminary analysis of the data type appeared in summary statistics.

4.1 Data description

The data used in this paper are obtained from DataStream International. The raw data consists of stock indexes of US, aggregate index of EMU countries, crude oil spot prices and eight stock indexes of eight European countries such as Croatia, Czech, Hungary, Poland, Romania, Russia, Ukraine, and Turkey. Sample period of employed data stock indexes are weekly based and spans from 1st September 2000 until 30th of March 2012 and in total includes 604 observations. It is worth to mention that several empirical studies are in favor of using weekly stock returns Ng (2000), for instance, indicates that using weekly data contributes to avoid nonsynchronous trading problems on stock returns. Moreover, as argued by Burns and Engle (1998), the use of daily returns might yield to underestimation of correlations among stock indexes. Taking into account the fact that mean and volatility spillover effects have mainly investigated by employing weekly data sample in previous empirical studies, implementation of the weekly data is likely more relevant in that sense. Since all indexes are appeared to be in national currencies, subsequently all of the indexes are adjusted to US Dollar by using each country's currency exchange rate against US dollar.

The broad market index, S&P 500 represents the global index and MSCI EU reflects regional market index and both of them have been considered to be so called “broad based index” respectively in US and European developed markets. In addition, MSCI EU represents the whole European developed markets. Being captured 90% of the capitalization of large and liquid securities. According to Bloomberg, (2012), MSCI index is consists of large and liquid securities and captures 90% of the capitalization of the broader benchmark. All the indexes are transformed to returns by taking the difference between log of indexes at time t and the log of their own value at time t-1. The data used for crude oil price is also weekly base. Moreover, macroeconomic variables employed in this study, such as exchange rate changes of each currency against Euro and USD, GDP of individual European emerging countries and total trade between US, EMU countries, and each of the local country is obtained quarterly. The data for crude prices are extracted from EAI and the macro variables are obtained both from DataStream and national statistics authorities of each European country.

4.2 Preliminary analysis

Descriptive statistics for each of the indexes of different markets are provided in Table 3. The mean returns during the sample period for all the European emerging and developing countries are positive and vary from 0.093% to 0.342%. All individual countries mean returns are higher than the US and European aggregate returns. During the sample period, the highest returns in USD are characterized in Romania and Russia, respectively, 0.342% and 0.308%. Turkey has a lowest mean return of 0,093%, followed by Croatia 0.192%. Moreover, the volatility of stock markets is much higher for Ukraine, Turkey and Russia with 7,610%, 7,470% and 5,420% standard deviations, respectively. It should be mentioned that mean returns and standard deviations for three Central Eastern European (CEE) emerging economies namely Czech, Hungary and, Poland are very close to each other. Although, the mean returns of stock markets are higher for developing countries, those markets are characterized with higher volatilities.

Table 3: Summary statistics of the weekly stock market returns, Sep.2000-Mar.2012[16]

	N. of OBS	Mean	Median	Max.	Min.	Std. dev.	Skewness	Kurtosis	Jarque-Bera Test	P-value
Croatia	604	0,192	0,296	16,338	-32,000	3,880	-1,301	13,732	3069,269	0,00
Czech	604	0,213	0,614	18,936	-32,780	4,120	-1,244	12,201	2286,562	0,00
Hungary	604	0,218	0,629	20,158	-35,320	4,480	-0,914	9,106	1022,980	0,00
Poland	604	0,219	0,497	24,003	-26,340	4,770	-0,646	6,799	405,471	0,00
Romania	604	0,342	0,474	15,310	-31,590	4,760	-1,224	9,492	1211,875	0,00
Russia	604	0,308	0,759	37,055	-28,720	5,420	-0,457	8,891	892,717	0,00
Ukraine	604	0,298	0,199	41,360	-39,163	7,610	-0,030	9,397	1030,108	0,00
Turkey	604	0,093	0,642	39,680	-75,781	7,470	-1,623	23,072	10404,940	0,00
EMU	604	-0,061	0,282	13,020	-27,340	3,780	-0,986	8,885	969,670	0,00
USA	604	-0,013	11,350	11,350	-20,084	2,700	-0,813	9,737	1208,992	0,00

Overall the simple summary statistics shows consistency with previous empirical studies by Bekaert and Harvey (1995), Goetzmann and Jorion, (1999), and so on. Both two studies indicate the distinguishing characteristics of emerging and developing countries which include higher average mean returns, low correlation with developed markets and higher volatility.

[16] Note: Weekly returns of indexes are calculated using following formula: $R_t = 100 * \ln\left(\frac{P_t}{P_{t-1}}\right)$, where Pt and Pt-1 are respectively log of indexes at time t, and one period lag.

Furthermore, all the indexes including those from regional and global stock market show negative skewness and excess kurtosis. In other words, third central moments indicates that return series are symmetric. Excess kurtosis assists to examine peakness of series distribution, more specifically, in our case series are relatively leptokurtic implying fat tails and higher peaks. The Jarque-Bera test reflects the results of assumption of normality for return series, where the null hypothesis that returns are normally distributed is rejected with obtained p values. All in all, descriptive statistics shown in Table 3 returns data are leptokurtic and have higher peaks and therefore, ARCH/GARCH type family models are relevant to deal with the property of the data.

The Table 4 reflects the correlation coefficients of each individual country with US, EU and Oil return which averagely range between 5.61 % and 82.8%. The full correlation coefficients including stock returns of each country with one another are provided in Appendix A1. The correlation between European emerging stock markets and developed markets are lower than the correlation coefficients between US and EU itself. This indicates feasible diversification opportunities for global investors. The Table 4 also shows that the compared to the US stock returns, European developed stock market returns are highly correlated with individual emerging and developing markets and this can be partially explained by higher financial integration among developed and emerging European countries.

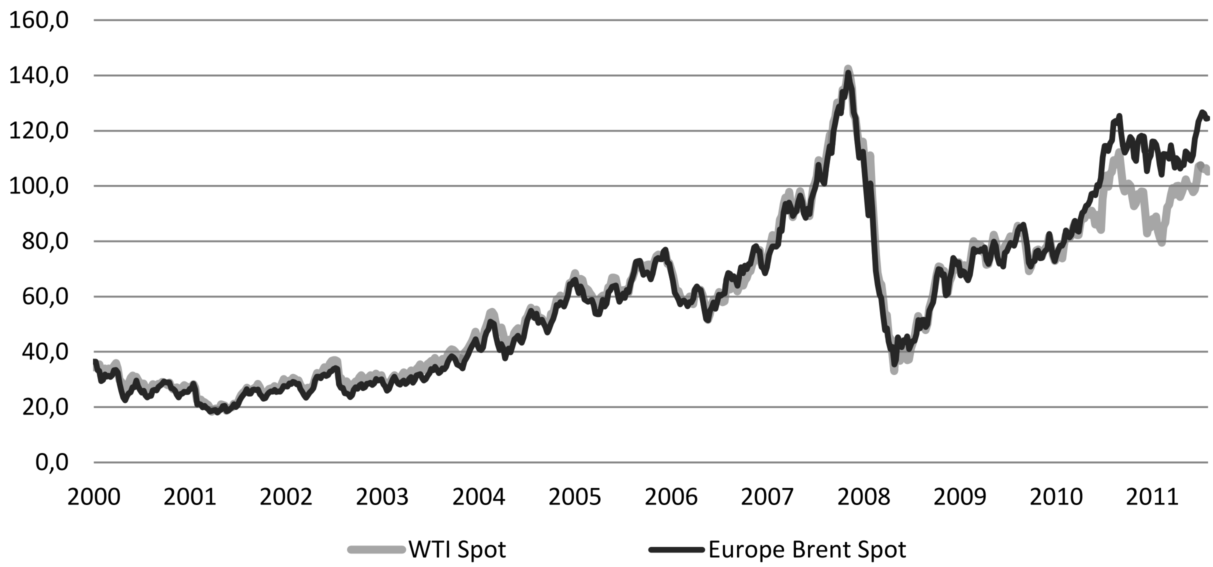
Table 4: Correlation coefficients of weekly stock market returns, over full sample period, 2000-2012

	US S&P500	EU MSCI	Brent Oil
Croatia Crobex	0,437	0,588	0,215
Czech PX	0,563	0,741	0,226
Hungary BUX	0,565	0,725	0,216
Poland WSE 20	0,577	0,71	0,23
Romania BET	0,403	0,524	0,203
Russia MICEX	0,478	0,573	0,353
Turkey ISE 100	0,503	0,583	0,129
Ukraine PFTS	0,141	0,178	0,087
US S&P 500	1,000	0,828	0,119
EU MSCI	0,828	1,000	0,186
Brent Oil	0,119	0,186	1,000

In addition Russian market is consists of two major stock market indexes, namely RTS and MICEX indexes. Due to the fact that two major indexes are highly correlated with 96% and the indexes and returns show the similar trend over the sample period, the only MICEX stock index is considered for further empirical estimation and analysis since it is most broad index in Russian economy. Finally, all the trend of indexes and the returns over the estimated period from September 2000 to March 2012 are visually presented in Appendix (Figure A1 and A2).

Furthermore, there are two main crude oil prices, namely West Texas Intermediate (WTI) and European Brent across the world used as major benchmarks. The price path of both of oil prices are presented in graph and the path of oil prices show that the huge difference between WTI and Brent started recent years, specifically in the end of 2010. Additionally, it should be noted that Brent is mainly based on Europe, and WTI is refined and used in US.

Graph 1: Weekly Crude Oil prices over 2000-2012 years.



The graph shows that over last decade the crude oil prices have demonstrated increasing trend and have kept being more volatile during 2006 and 2008 that overlap with Recent Financial Crisis. Regnier, (2007) argues that higher volatility in manufacturing products yielded to crude oil price to have unusual high path. Recent trends seem to predict that the increase in prices will be continued in coming years. Since the paper studies the volatility and return spillover effects towards European emerging economies, it is reasonable to use Europe Brent crude oil price.

5. Econometric methodology

The following chapter will address the econometric methodology applied in this study. In the first place, the primary spillover models introduced by several distinguishing authors are briefly discussed. Second, the core empirical models such as constant and conditional spillover models are introduced. Then, following sub-sections shed more light on spillover effects assessed by variance ratio and, finally dummy spillover model is presented.

5.1 Empirical model and estimation framework

The generalized autoregressive conditional heteroskedasticity (GARCH) process is recognized model for analysis of volatility and return spillovers amongst international financial markets. As the primary model the empirical modeling in this paper includes several econometric estimation steps that properly need to be implemented. The main econometric specification, namely AR(1)-GJR-GARCH allows to test spillover effects and investigate how much conditional variance individual country *j* has been explained respectively by Global Factor US (GF US), Regional Factor EU (RF EU), local factor (own market of country *j*) as well as the World Factor Oil Price (WF Oil).

The Bekaert and Harvey (1995) introduced the volatility spillover to investigate the country specific volatility which is determined by world and local market factors. Later, depending on the aim of the study Ng (2000), Christiansen (2004) and Baele (2005) developed volatility spillover models by allowing more new "innovations" to be explained by models. Thus, the empirical modeling of this paper is constructed by using econometric specifications proposed by Ng (2000), Christiansen (2004) and Baele (2005).

The volatility modeling applied by Ng (2000) is based of two steps. First step is consisting of estimation of bivariate GARCH model for global and regional effects which are respectively US and Japanese Stock returns. In order to avoid spillover effects from US to Japanese market (and vice versa) residuals from world factors are orthogonalized. In the second step orthogonalized shocks as well as one period lagged return from US and Japanese markets are used as explanatory variables in univariate GARCH model for national stock market returns of Pacific Basin countries. Thus, the first approach is based multiple steps estimation procedures that allows to capture local shocks, as well as the news originating spillover effects from global (US) and regional effects (Japan).

Following the Ng (2000) and Bekaert and Harvey (1997), study by Christiansen (2004) also examines the volatility spillover effects through multiple estimation procedures. Christiansen (2004) applies the similar econometric approach analyses the volatility spillover on European Bond Markets. The empirical modeling follows three steps estimation procedures. First and second steps estimate the US and European bond returns which is quite similar to approach used by Ng (2000) and Bekaert and Harvey (1995). In the final step, including one period lagged returns and market shocks by US and European Aggregate Stock market return as explanatory variables in univariate autoregressive GARCH allows to investigate mean and volatility spillover effects on bond market of individual European developed economies. Furthermore, Christiansen (2004) captures the spillover effects on stock market of the same countries by adding one more estimation step. However, in the latter paper the author applies modeling in multivariate framework evolving by Dynamic Conditional Correlation (DCC) introduced by Engle (2002) and Tse et al., (2002) and conditional variance is evolved according to GJR-GARCH model. The latter paper allows to more efficient investigation of volatility spillover from internal and external shocks.

The core empirical modeling and estimation framework in this paper is based on Ng (2000), Bekaert et al., (2005), and Christiansen (2004). More specifically, the four sources, namely pure local shocks of county j, a global US shocks, a regional European shocks as well as shocks from oil price innovations are allowed to for estimation of conditional volatility of country j's stock returns. The models and estimation framework follow Ng 2000 and mostly Christiansen (2004) approaches. In addition, my paper examines the mean and volatility spillover from oil shocks to country j' stock returns, too. Thus, the four steps univariate autoregressive (AR) GJR-GARCH (1, 1) is applied. In order to get rid of serial correlation and avoid ortogonalization GJR-GARCH model will evolve according to AR (1) process. GJR-GARCH also known as Threshold GARCH model introduced by Glosten, Jagannathan and Runkle (1993) is a simple extension of GARCH with an additional term added to account for possible asymmetries. Additionally, separate asymmetrical test will be explored toward each spillover effects in primary constant spillover model. Moreover, the conditional model will be used to test the conditional spillover intensities and ultimately, all the variances from various models as well as sub-periods will be quantified. Finally, for evaluation of European Union enlargement statement, the AR-GJR-GARCH Dummy model will be introduced.

5.2 Constant spillover models

The spillover models are constructed in following below indicated steps. First step is to construct and estimated the bivariate model for Brent oil spot price including a constant and one period lagged return of oil price.

Step 1: *World Factor Oil Returns (WF Oil):* The unconditional mean for oil returns in equation (1) changes according to first order autoregressive (AR) process which allows avoiding possible serial correlation. The unconditional variance evolves based on asymmetric GJR-GARCH (1, 1) which is specified equation (2);

$$R_{oil,\boldsymbol{t}} = \Phi_{0,oil} + \Phi_{1,oil} R_{oil,t-1} + \epsilon_{oil,t} \tag{1}$$

$$h_{oil,\boldsymbol{t}} = \omega_{oil} + a_{1,oil}\varepsilon^2_{oil,t-1} + \beta_{oil} h_{oil,t-1} + \alpha^*_{2,oil}\epsilon^2_{oil,t-1} I_{oil,t-1} \tag{2}$$

$$\epsilon_{oil,t} | I_{t-1} \sim N(0, h_t), \tag{3}$$

The terms $\Phi_{0,oil}$ and $\Phi_{1,oil}$ are parameter of estimates and $\epsilon_{oil,t}$ denote a real valued stochastic process or an idiosyncratic shock which is assumed normally distributed with zero mean. The term I_{t-1} is information set available through time t-1. Subsequently, the term $h_{oil,t}$ stands for conditional variance.

The model allows to show how volatility behaves differently by having effects of good and bad news, where, $I_{oil,t-1} = 1$ if $\epsilon_{oil,t} < 0$ and$\omega_{oil} > 0, a_{1,oil}, \beta_{oil}, a_{1,oil} + \frac{1}{2}\alpha^*_{2,oil} \geq 0$ and$a_{1,oil} + \beta_{oil} + \frac{1}{2}\alpha^*_{2,oil} \leq 1$. When α^*_2 positive sign then “bad” news has seems to have a more effect than does “good” news. In other words, negative shocks have more noticeable effect on volatility than positive shocks.

Step 2: *Global Factor US (GF US):* By following the same previous AR (1) specification and asymmetric GJR-GARCH model described in step one, the mean and conditional variance for the US stock returns can be through univariate model respectively, in equations (4) and (5);

$$R_{US,\boldsymbol{t}} = \Phi_{0,US} + \Phi_{1,US} R_{US,t-1} + \varphi_{US} R_{oil,t-1} + \vartheta_{US}\epsilon_{oil,t} + \epsilon_{US,t} \tag{4}$$

$$h_{US,\boldsymbol{t}} = \omega_{US} + a_{1,US}\epsilon^2_{US,t-1} + \beta_{US} h_{US,t-1} + \alpha^*_{2,US}\epsilon^2_{US,t-1} I_{US,t-1} \tag{5}$$

$$\epsilon_{US,t} | I_{t-1} \sim N(0, h_t), \tag{6}$$

As in step one, the terms $\Phi_{0,US}$ and $\Phi_{1,US}$ are parameter of own US stock returns. Step two, also include effects from one period passed oil price returns, where estimated parameter is given by in φ_{US}. additionally, and variables $\vartheta_{US}\epsilon_{oil,t}$ and $\epsilon_{US,t}$ account for respectively, idiosyncratic oil shocks with estimated parameter and own US shocks.

Step 3: *Regional Factor EU (RF EU)***:** The univariate model for stock returns of sixteen European Monetary Union (EMU) countries stock market index can be expressed as following;

$$R_{EU,\boldsymbol{t}} = \Phi_{0,EU} + \Phi_{1,EU}R_{EU,t-1} + \gamma_{US}R_{US,t-1} + \varphi_{EU,}R_{oil,t-1} + \vartheta_{EU}\epsilon_{oil,t} + \theta_{US}\epsilon_{US,t} + \epsilon_{EU,t} \quad (7)$$

The equation (7) indicates that European developed markets' stock returns correspondingly depend on its own one period lagged returns, one period past US returns, as well as one period lagged oil returns, where last two lagged returns claim mean spillovers for European advance stock markets. Eventually, the conditional variance equation for EU stock returns evolves according to GJR-GARCH (1, 1) where idiosyncratic EU shock $\epsilon_{EU,t}$ is normally distributed with zero mean;

$$h_{EU,\boldsymbol{t}} = \omega_{EU} + a_{1,EU}\varepsilon^2_{EU,t-1} + \beta_{EU}h_{EU,t-1} + \alpha^*_{2,EU}\epsilon^2_{EU,t-1}I_{EU,t-1} \quad (8)$$

Eventually, idiosyncratic Oil price shocks and contemporary US residual $\epsilon_{US,t}$ account for volatility spillovers for EU developed market.

Step 4: *European Country j's stock returns***:** As a final step, the univariate return and volatility models are specified for each individual European stock returns. As previously, in order to avoid serial correlation one period lagged return of each individual stock return is included and thus, the conditional mean for country j is given as following (j=1, 2….8);

$$\begin{aligned} R_{j,\boldsymbol{t}} = c_{0,j} + c_{1,j}R_{j,t-1} + \gamma_j R_{US,t-1} + \delta_j R_{EU,t-1} + \varphi_j R_{oil,t-1} + \\ +\theta_j\epsilon_{US,t} + \psi_j\epsilon_{EU,t} + \vartheta_{\boldsymbol{j}}\epsilon_{oil,t} + \epsilon_{j,t} \end{aligned} \quad (9)$$

The first row (line) in equation (9) introduces the mean spillovers and parameter estimatesγ_j, δ_j and φ_j respectively measure the significance the US, EU and Oil mean spillovers into each national stock market of European countries. The second raw (line) in equation (9), presents the volatility spillovers from GF US, the RF EU and WF Oil and respectively following parameter estimates θ_j, ψ_j and $\vartheta_{\boldsymbol{j}}$ empirically tests the significance of volatility spillovers The idiosyncratic shock, $\epsilon_{j,t}$ for country j is also normally distributed and the conditional variance of the residual is specified below, where

$$h_{j,\boldsymbol{t}} = \omega_j + a_{1,j}\varepsilon^2_{j,t-1} + \beta_j h_{j,t-1} + \alpha^*_{2,j}\epsilon^2_{j,t-1}I_{j,t-1} \quad (10)$$

5.3 Volatility spillover effects: Variance ratios

The unexpected returns can also be expressed by ε_t as following;

$$\varepsilon_{US,t} = \epsilon_{US,t} + \epsilon_{oil,t} \tag{11}$$

$$\varepsilon_{EU,t} = \theta_{EU}\epsilon_{US,t} + \vartheta_{EU}\epsilon_{oil,t} + \epsilon_{EU,t} \tag{12}$$

$$\text{Country j's: } \varepsilon_{j,t} = \theta_j\epsilon_{US,t} + \psi_j\epsilon_{EU,t}\epsilon_{,t} + \vartheta_j\epsilon_{oil,t}\epsilon_{,t} + \epsilon_{EU,t} \tag{13}$$

The terms $\epsilon_{US,t}$, $\epsilon_{EU,t}$and $\epsilon_{oil,t}$ are assumed to be independent by construction. The last term in equation (13) accounts for remaining effects which is explained by innovations evolved in individual European stock markets. The conditional variance for unexpected returns can be calculated by taking variances of different terms in equation (13), and it is given below;

$$\text{Country j's: } h_{j.t} = E(\epsilon_{US,t}|\psi_{t-1}) = \theta_j^2 h_{US,t} + \psi_j^2 h_{EU,t} + \vartheta_j^2 h_{oil,t} + \sigma_{j,t}^2 \tag{14}$$

The term$h_{US,t}, h_{oil,t}. and\ h_{EU,t}$ are respectively denotes squared US, EU and idiosyncratic oil market shocks. Consequently, the total variance for individual developing European Stock market consists of variances of Global Factor US (GF US), Regional Factor EU (RF EU), and idiosyncratic World Factor Oil price (WF Oil) as well as variance of its own returns.

Furthermore, in order to measure the variances of the unexpected return of country j the estimated coefficients from unconditional models are utilized. Ultimately, by using equation (13) the variances can be computed and the expression for "variance ratios" are specified as following;

$$VR_{j,t}^{US} = \frac{\theta_{j,t-1}^2 \sigma_{US,t}^2}{h_{j.t}} \tag{15}$$

$$VR_{j,t}^{EU} = \frac{\theta_{j,t-1}^2 \sigma_{EU,t}^2}{h_{j.t}} \tag{16}$$

$$VR_{j,t}^{OIL} = \frac{\theta_{j,t-1}^2 \sigma_{oil,t}^2}{h_{j.t}} \tag{17}$$

$$VR_{j,t}^{Own} = 1 - VR_{j,t}^{US} - VR_{j,t}^{EU} - VR_{j,t}^{OIL} \tag{18}$$

Respectively, equations (15), (16), and (17) quantify the variance ratios of various transmitted shocks in total conditional variances for country j, and equation (18) simply denotes for remaining variances which is explained by pure local factors.

5.4 Asymmetric spillover tests on stock returns

In order to examine how stock returns of eight (8) individual European countries react asymmetrically to changes in global and regional stock markets as well as oil markets, the equation (19) introduces the asymmetric effects of investigated stock markets returns towards changes from GF US, RF EU and WF Oil effects, in terms of decrease and increase of stock returns and negative and positive on stock innovations on shocks.

$$R_{j,t} = c_{0,j} + c_{1,j}R_{j,t-1} + \gamma_{0,j}R^{-}_{US,t-1} + \gamma_{1,j}R^{+}_{US,t-1} + \delta_{0,j}R^{-}_{EU,t-1} + \delta_{1,j}R^{+}_{EU,t-1} + \varphi_{1,j}R^{-}_{oil,t-1} +$$
$$+ \varphi_{1,j}R^{+}_{oil,t-1} + \theta_{0,j}\epsilon^{-}_{US,t} + \theta_{1,j}\epsilon^{+}_{US,t} + \psi_{0,j}\epsilon^{-}_{EU,t} + \psi_{1,j}\epsilon^{+}_{EU,t} + \vartheta_{0,j}\epsilon^{-}_{oil,t} + \vartheta_{1,j}\epsilon^{+}_{oil,t} + \epsilon_{j,t} \quad (19)$$

In equation (19) both lagged returns and shocks are allowed to have both negative and positive values. More specifically, the previously modeled mean spillovers are investigated by decomposing returnsR_{t-1}, in two variables which respectively represents decrease (R^{-}_{t-1}) and increase (R^{+}_{t-1}) in returns of GF US, RF EU and WF Oil returns. In the same manner, volatility spillovers shocks can be distinguished ϵ^{-}_{t} and ϵ^{+}_{t} that are respectively proxy for negative and positive shocks. Subsequently, each of the variables that accounts for asymmetric effects appeared in equation (19) is constructed as following:

$R^{-}_{t-1} = R_{t-1}$ If $R_{t-1} < 0$ and zero (0) otherwise

$R^{+}_{t-1} = R_{t-1}$ If $R_{t-1} > 0$ and zero (0) otherwise

$\epsilon^{-}_{t} = \epsilon_t$ If $\epsilon_t < 0$ and zero (0) otherwise

$\epsilon^{+}_{t} = \epsilon_t$ If $\epsilon_t > 0$ and zero (0) otherwise

Moreover, the investigation of asymmetric responses of individual stock returns to oil price changes has paramount importance which extensively analyzed in previous empirical studies mainly in developed markets. Amongst them, Mork (1989), Ferderer (1996), Sadorsky (1999) and Ciner (2001) found that asymmetric effects of oil prices changes both in stock returns and on macroeconomic factors. Ferderer (1996), for example, indicates that oil price shocks tend to adversely affect to macroeconomic indicators in two main ways, namely increase in oil prices and volatility shocks. Additionally, empirical study by Sadorsky (1999) also finds asymmetric effect of oil price on economy and concludes that positive shocks to oil prices tend to depress real stock returns. Therefore, taking into account the broad empirical analysis of oil prices on developed markets, asymmetric response of national stock returns of European countries in particular to oil price changes and volatilities will be estimated and analyzed.

5.5 Instrumental variables in the spillover model

In addition to unconditional spillover model the conditional spillover driven by instrumental economic variables introduced by Ng (2000) is also described via equations (20)-(23). The model includes parameters that relax the time varying constant spillover. As the degree of international relationships via trades change as well as the degree of regional integration evolves over time, it is apt to investigate how spillover weight parameters are captured by some local and regional instrumental variables. To that reason we allow following model to account for the notion of conditionality mentioned above;

$$\gamma_{j,t-1} = v^{i} X_{j,t-1}^{US} \tag{20}$$

$$\theta_{j,t-1} = w^{i} X_{j,t-1}^{US} \tag{21}$$

$$\delta_{j,t-1} = p^{i} X_{j,t-1}^{EU} \tag{22}$$

$$\psi_{j,t-1} = q^{i} X_{j,t-1}^{EU} \tag{23}$$

Where, v' and w' are (3x1) vectors of parameters, which quantify the impact of local information variables on the conditional spillover effects from global factor US, while p' and q' are (3x1) are also vector of parameters measuring spillover effects from regional European effect. The economic variables in $X_{i,t-1}^{US}$ include currency of country j's constant exchange rate against US dollar, and total exports from and imports to US as a ratio of GDP of country j. Subsequently, the variables $X_{i,t-1}^{EU}$ include currency of country j's constant change of exchange rate against EURO, and trade with sixteen European Monetary Union (EMU 16) countries as ratio of GDP of country j. It should be mentioned that all the countries investigated in paper are either non Euro zone or EU members. Currency effects on the volatility and correlation of stock markets have been widely studied. Shocks caused by exchange rate fluctuations can readily transmit to international financial markets. Moreover, economic integration is defined as the main motivation behind using the ratios of trade country j to US and EMU (16) to GDP (Ng, 2000).

5.6 AR(1)-GJR-GARCH(1,1)- Dummy variable model

Furthermore, the membership to European Union (EU) also led to development of stock exchange markets of new joined member countries such as Czech, Hungary, Poland and Romania. In order to analysis the effect EU Enlargement on mean and volatility spillovers from regional European market the dummy variable model is employed. The dummy variable is created such that it takes value zero (0) before the EU enlargement and value one (1) after that. More explicitly, from September 8th 2000 until April 30th2004 and from September 8th 2000 till December 31st 2006 the dummy 0, and from May 1th 2000 till March 30th 2012 and from January 8th 2000 till January 1st 2007 the dummy value 1 is applied respectively to account for first and second wave of EU Accession of aforementioned countries[17]. The unconditional AR (1) –GJR–GARCH (1,1) Dummy variable model is presented in below formula;

$$R_{j,t} = c_{0,j} + c_{1,j}R_{j,t-1} + \gamma_j R_{US,t-1} + (\delta_{0,j} + \delta_{1,j}D_{t-1})R_{EU,t-1} + \varphi_{1,oil}R_{oil,t-1} + \\ +\theta_j \epsilon_{US,t} + (\psi_{0,j} + \psi_{1,j}D_{t-1})\epsilon_{EU,t} + \vartheta_{j}\epsilon_{oil,t} + \epsilon_{j,t} \tag{24}$$

However, it should be also noted, that the equation (24) do not introduce “new fundamental” explanatory variables in a sense that are almost the same as in previous models. The quantification of dummy variable is also described in throughout below equations.

$$VR_{j,t}^{EU,dum} = \frac{(\psi_{0,j}+\psi_{1,j}D_{t-1})^2\sigma_{eu,t}^2}{h_{j.t}} \tag{25}$$

$$VR_{j,t}^{Own} = 1 - VR_{j,t}^{US} - VR_{j,t}^{EU,dum} - VR_{j,t}^{OIL} \tag{26}$$

Thus, the AR(1)–GJR-GARCH (1,1) dummy model specified in equation (24) and relevant variance ratios will aim to examine respectively the possible effect (decrease or increase) in constant spillover parameters.

6. Empirical results

This section presents the empirical findings. First and foremost, the estimated results for constant spillover model over entire period are reported. Second, sensitivity analysis for different specifications is discussed. Then, the estimation results before and after Global Financial Crises of 2008 are described. The next sub-section draws an attention tested asymmetric results in response to changes in positive and negative shocks. Fifth and sixth sub sections, respectively, present empirical findings on conditional and dummy spillover model.

[17] Czech Republic, Hungary, Poland, Baltic States, Slovakia, and Slovenia joined to EU according to first wave of EU enlargement in 2004. The second wave defines the membership of Romania and Bulgaria in 2007.

6.1 Constant spillover model

According to econometric modeling, in the first place bivariate and univariate constant spillovers models for global, regional and world factors are estimated and relevant coefficients for Oil (WF Oil), US (GF US) and EU (RF EU) are reported in Table 5. According to estimation findings the own one period lagged return of oil price, the US and EU returns are found to be significant respectively at 1%, 10% and 5% level. Judged by scale and sign, coefficients for one lagged own returns are also very low and negative for US and EU stock returns implying negative weak first-order autocorrelations (ACF).

Table 5: Estimation results for returns of WF OIL, GF US and RF EU returns.

	Φ_0	Φ_1	φ	ϑ	γ	θ	ω	α	$\alpha*$	β
Oil	0.178 (0.293)	0.216* (0.000)					1.126* (0.000)	-0.011 (0.736)	0.109* (0.007)	0.881* (0.000)
US	0.064 (0.452)	-0.074^ 0.064	-0.010 0.551	0.042# (0.015)			0.426* (0.000)	-0.021 (0.459)	0.352* (0.000)	0.771* (0.000)
EU	0.112^ (0.099)	-0.091# (0.045)	-0.007 (0.673)	0.125* (0.000)	0.064 0.190	0.959 (0.000)	0.250* (0.001)	0.148* (0.000)	0.061 (0.266)	0.748* (0.000)

Note: p-values are in the parentheses and *,#, and ^ represent significance level at 1%, 5% and 10% respectively

Although it is not the primary focus of this paper, however, it can be noted that, that oil volatility spillovers are also appeared to drive significantly both the US and EU stock markets and the Wald tests[18] of no spillovers effects are strongly rejected. The result is similar for study explored by Horng and Wang (2008), where the authors find strong presence asymmetric effects and significant oil markets shocks to US equity market using asymmetric-IGARCH(1,2). The result also shows that EU developed market is highly influenced by US volatility spillover effects, and the Wald test indicating no spillovers effects from US, $H_0: \gamma_{EU} = \theta_{EU} = 0$ is also highly rejected. However, there is no evidence of mean spillover from the US to EU developed market. Additionally, for all three returns the variances are appeared to be persistent and stationary, as $\alpha + \beta + 1/2\alpha^* \leq 1$. In the tested model, coefficient estimate $\alpha*$ which takes into account the asymmetric effect in conditional variance is highly significant in bivariate model for oil price returns and univariate model US stock returns.

[18] The Wald tests for the US and EU are following: $H_0: \varphi_{US} = \vartheta_{US} = 0$ and $H_0: \varphi_{EU} = \vartheta_{EU} = 0$

The empirical findings for the mean and return volatility spillovers for national stock market of European countries are reported and discussed in the following paragraphs. As shown in Table 6, the first-order autocorrelation parameters of individual countries are significant only for Poland and Ukraine. As previously specified in equation (9), the spillover effects into national stock returns are transmitted respectively by one period lagged returns and market shocks from the US and EU stock markets as well as Oil market.

Table 6: The constant spillover model estimation results for individual country j's stock returns over entire sample period (September 2000 - March 2012)

	Croatia	Czech[19]	Hungary	Poland	Romania	Russia	Turkey	Ukraine
c_0	0.288#	0.336*	0.282#	0.207^	0.359#	0.349#	0.215	0.236
	(0.014)	(0.001)	(0.039)	(0.081)	(0.018)	(0.020)	(0.250)	(0.267)
c_1	0.058	-0.070	-0.062	-0.100#	-0.025	-0.074	-0.081	0.105#
	(0.207)	(0.098)	(0.148)	(0.020)	(0.551)	(0.061)	(0.104)	(0.032)
δ	0.134^	-0.031	0.116	-0.031	0.196#	-0.004	0.103	0.464
	(0.056)	(0.658)	(0.141)	(0.698)	(0.044)	(0.958)	(0.386)	(0.056)
γ	-0.035	-0.166#	0.807	-0.236*	-0.121	0.066	-0.002	-0.274#
	(0.603)	(0.015)	(0.067)	(0.100)	(0.234)	(0.528)	(0.187)	(0.023)
φ	0.024	-0.054#	0.047	0.072*	0.077#	0.180*	0.049	-0.096*
	(0.289)	(0.020)	(0.102)	(0.009)	(0.015)	(0.005)	(0.320)	(0.007)
ψ	0.760*	1.092*	1.239*	1.203*	0.923*	0.701*	1.009*	0.301*
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
θ	0.431*	0.780*	0.866*	0.979*	0.605*	0.782*	1.046*	0.280*
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
ϑ	0.138*	0.179*	0.202*	0.231*	0.227*	0.364*	0.212*	0.069
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.175)
ω	1.687	0.379	2.589	0.341#	0.389^	0.499	0.189#	0.947
	(0.000)	(0.005)	(0.001)	(0.039)	(0.052)	(0.006)	(0.050)	(0.002)
α	0.158*	0.125*	0.063	0.115*	0.104*	0.122*	0.029#	0.236*
	(0.002)	(0.000)	(0.215)	(0.003)	(0.000)	(0.002)	(0.038)	(0.000)
α*	0.108	-0.027	0.161#	-0.005	-0.020	0.001	0.058*	0.06
	(0.130)	(0.468)	(0.025)	(0.893)	(0.454)	(0.998)	(0.001)	(0.287)
β	0.606*	0.836*	0.619*	0.853*	0.884*	0.849*	0.936*	0.767*
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)

Note: P values are in the parentheses and *, #, and ^ represent significance level at 1%, 5% and 10% respectively

Judged by scale and p-values of parameter estimated and the strong evidences of volatility spillovers from the US and EU stock markets as well as oil market are found to be highly

[19]In Tables the Czech Republic is appeared only as Czech.

significant for all national stock markets (p-value of 0,000) The parametric Wald tests of no volatility spillovers on stock returns are also highly rejected (Table 7).

The null hypotheses of joined Wald tests employed for estimation purpose is given below;

$H_0^1: \varphi_j = \vartheta_j = 0$: No Oil prices spillover effects on stock returns

$H_0^2: \gamma_j = \theta_j = 0$: No Global US spillover effects on stock returns

$H_0^3: \delta_j = \psi_j = 0$: No Regional EU spillover effects on stock returns

$H_0^4: \varphi_j = \delta_j = \gamma_j = 0$: No mean spillover effects on stock returns

$H_0^5: \vartheta_j = \theta_j = \psi_j = 0$: No volatility spillover effects on stock returns

Table 7: Wald tests for constant spillover model for entire sample period[20] from September 2000 to March 2012)

	$Wald_1$	$Wald_2$	$Wald_3$	$Wald_4$	$Wald_2$
CRO	14.797*	46.178*	67.533*	2.201^	96.515*
	(0.001)	(0.000)	(0.000)	(0.086)	(0.000)
CZE	31.864*	244.226*	194.387*	5.164*	302.17*
	(0.000)	(0.000)	(0.000)	(0.002)	(0.000)
HUN	20.727*	242.231*	168.936*	4.199	466.16*
	(0.000)	(0.000)	(0.000)	(0.056)	(0.000)
POL	39.776*	319.601*	143.008*	7.549*	418.02*
	(0.001)	(0.000)	(0.000)	(0.001)	(0.000)
ROM	25.480*	56.351*	79.565*	4.217*	133.75*
	(0.000)	(0.000)	(0.000)	(0.006)	(0.000)
RUS	52.362*	119.239*	28.973*	2.847#	142.51*
	(0.000)	(0.000)	(0.000)	(0.037)	(0.000)
TUR	9.4069*	69.932*	35.113*	1.163	75.585*
	(0.002)	(0.000)	(0.000)	(0.322)	(0.000)
UKR	4.9343*	14.665*	21.380*	17.796*	16.151*
	(0.008)	(0.000)	(0.000)	(0.000)	(0.000)

Note: P values are in the parentheses and *, #, and ^ represent significance level at 1%, 5% and 10% respectively.

The presence of significant mean spillovers from the US stock markets is found with negative coefficients for Poland, Czech Ukraine. The weak mean spillover effect form regional EU market is statistical significant for Romania. Thus, results show some mean spillover effects from global US, however, the mean spillovers from regional market can be considered negligible. According to coefficient estimates summarized on Table 6, the mean spillover from oil returns significantly influence stock returns of Czech, Poland, Romania and Russia and the Wald tests are rejected, accordingly. Judged by scale of coefficient the lagged oil return is found to be highly positive and significant for Russia (φ_{oil}, 0.180). This finding can be interpreted by the fact that the Russia is only oil exporting country amongst eight investigated European countries. In other words, oil returns seem to highly and positively

[20] $Wald_1$, $Wald_2$,$Wald_3$, $Wald_4$ and $Wald_5$ tests are $\chi2(2)$ distributed under aforementioned null hypothesis.

drive Russian stock returns. On the other hand, volatility spillover effects driven by oil shocks area appeared to be strongly significant and associated with positive parameter signs for all countries, except Ukraine. On the other hand, it should be noted that the asymmetrical volatility process is stationary for all examined national markets, since $\alpha + \beta + 1/2\alpha^{*} \leq 1$. Since the univariate constant spillover models are constructed using GJR-GARCH (1, 1) model, which captures asymmetric effects for stock returns[21]. The presence of asymmetric effects is found to be significant only stock returns of Hungary and Turkey (Table 6). In other words, some evidences of leverage effect (Ding et. al., 1993), implying that negative shocks (bad news) tend to influence stock returns more than positive shocks (good news) are reported only in case of Hungary and Turkey.

The effects of volatility spillovers for country j are evaluated according to variance ratios namely, VR-US from global factor, VR-EU from regional factor, VR-OIL from world factor and local VR-OWN are quantified and reported in Table 8. The variance ratios specified in equations (15)-(18) assess the proportions of unexpected returns in conditional variance from local and external sources. According to mean of variance ratios, the US volatility spillovers are found to be most dominating factor for conditional variance of unexpected returns for all investigated countries, except Croatia and Romania. More specifically, on average 9.4%-26.7% of volatility spillovers are contributed by US market shocks.

Table 8: Summary statistics for variance ratios for entire period (from Sep. 2000-Mar.2012[22])

		CRO	CZE	HUN	POL	ROM	RUS	TUR	UKR
VR EU	Mean	22.713	26.716	24.583	16.851	20.055	10.866	13.855	6.367
	Std.dev	0.260	0.276	0.261	0.198	0.225	0.160	0.199	0.008
VR US	Mean	16.187	26.798	25.028	24.837	18.707	21.726	24.791	9.492
	Std.dev	0.206	0.260	7.077	0.258	0.211	0.244	0.276	0.180
VR OIL	Mean	8.219	7.802	0.070	20.386	9.576	16.932	6.042	3.132
	Std.dev	0.145	0.311	0.115	0.219	0.146	0.210	0.107	0.078
VR OWN	Mean	52.880	38.681	43.331	37.923	51.656	50.474	55.310	81.008
	Std.dev	0.345	0.311	0.322	0.292	0.325	0.334	0.242	0.277

In contrast, on average the EU market shocks account for 6.3%-25.7% of volatility spillovers which is relatively less than global US volatility spillovers. The result aids to answer the second research question that the US stock returns, thereby US S&P 500 index has most

[21] Symmetrical AR(-1) GARCH (1,1) model is also estimated and reported in Table A3 in Appendix A. Judged by the signs and scale of significant coefficients, it should be noted that symmetrical and asymmetrical models present almost similar results for all eight individual stock markets.
[22] The obtained variances are illustrated in Figure A4-3 in Appendix A.

magnitude effect on national stock markets of European national markets. Judged by oil volatility spillover coefficients, the highest oil volatility spillovers effects are found in case of Russia (VR OIL=16.9%). Finally, pure local shocks are more pronounced compared to external shocks, and on average for CEE countries mean of local shocks are relatively small compared to other European countries. The interpretation to this is more likely due to the fact that CEE countries are most integrated to regional and are considered the highly emerged stock markets amongst other examined countries

Additionally, I also empirically tested the pure regional EU and global US mean and spillover effects by excluding the oil price effects[23] and eventually, for quantitative evaluations the variance ratios are computed and reported in Table 9. The assessment by excluding oil effect also confirms the dominating role of US volatility spillovers over those from EU spillover effects. In other words, the unexpected returns of shocks on investigated European stock markets are mostly driven by global US volatility effects and local shocks.

Table 9: Summary statistics (Mean and std. dev.) for Variance ratios while excluding Oil effect over entire period (from September 2000-March 2012)

		CRO	CZE	HUN	POL	ROM	RUS	TUR	UKR
VR EU	Mean (%)	25.569	30.259	27.312	24.342	21.681	16,543	16,557	8,139
	Std.dev	0.281	0.299	0.279	0.257	0.256	0.221	0.227	0.158
VR US	Mean (%)	18.624	29.593	27.145	31.348	19.894	26,212	30,730	10,936
	Std.dev	0.233	0.283	0.200	0.300	0.239	0.281	0.299	0.207
VR OWN	Mean (%)	55.805	40.146	45.542	44.276	58.423	57,243	56,578	80,923
	Std.dev	0.341	0.324	0.331	0.329	0.333	0.331	0.344	0.276

The time series of variance ratios are also plotted for each country. The obtained variance ratios are clearly illustrated the proportions of volatility spillovers (Figure A3: Appendix).

6.2 Sensitivity analysis

In previous section, I have shown that, the mean spillover effects from regional EU stock market is statistical insignificant. The interpretation for this can be due to existence of high correlation (0.828) between the US and EU stock market. Taking into account the reason of high correlation, so called sensitivity analysis is implemented under three main specifications within estimation framework of constant spillover model. The analysis is mainly based on omitting the U.S one period lagged return in estimation framework by applying redundant

[23] The empirical results and Wald tests are reported, respectively in Table A6 -1 and A6-2 in Appendix A.

variable test. Table 10 reports the results for various specifications[24]. The first specification considers the exclusion of US one period lagged return. Next, using the EU stock return at time t, instead of at time t-1 is considered prior to second specification. The main proxy for specification II is the trading time zone effect on stock markets, in which trading same trading hours in stock exchange markets are considered[25]. Finally, omitting one lagged US return and including regional EU lagged return only at time t is implemented in third specification.

Table 10: Estimated results for three specifications over entire period (2000-2012) [2]

	(I)		(II)		(III)	
	δ	ψ	δ	ψ	δ	ψ
Croatia	0.108#	0.025	-1.479^	0.013	-1.732#	0.010
	(0.018)	(0.274)	(0.056)	(0.573)	(0.026)	(0.652)
Czech	0.097#	0.044^	0.340	0.057#	0.138#	0.048^
	(0.032)	(0.054)	(0.658)	(0.023)	(0.032)	(0.055)
Hungary	0.176*	0.045	-1.277	0.037	-1.285*	0.034
	(0.002)	(0.110)	(0.141)	(0.208)	(0.136)	(0.228)
Poland	0.144*	0.064#	0.341	0.075*	0.223	0.068#
	(0.003)	(0.019)	(0.698)	(0.009)	(0.806)	(0.017)
Romania	0.108^	0.080#	-0.254#	0.061^	-2.223#	0.060^
	(0.053)	(0.011)	(0.034)	(0.072)	(0.024)	(0.073)
Russia	0.040	0.106*	0.047	0.110*	-0.167	0.104*
	(0.391)	(0.006)	(0.951)	(0.007)	(0.841)	(0.010)
Turkey	0.066	-0.021	-1.127	0.041	-1.348	0.040
	(0.499)	(0.707)	(0.386)	(0.440)	(0.289)	(0.447)
Ukraine	0.270*	-0.070#	-3.089*	0.013*	-5.252*	-0.133*
	(0.000)	(0.036)	(0.000)	(0.000)	(0.000)	(0.000)

Note: P values are in the parentheses and *,#, and ^ represent significance level at 1%, 5% and 10% respectively

The findings on first specification indicates that with exclusion of US one period lagged return, the mean spillover effects from regional market becomes significant for Croatia, Czech, Hungary, Poland, and Ukraine. None of the changes are reported for oil mean spillover effects. However, we cannot observe any significant changes by implying EU returns at time *t* instead of *t-1* in second specification. Finally, the findings on the third specification confirm that by omitting US lagged return, the EU lagged returns turn out to be statistical significant for Croatia, Czech, Hungary, Poland, Romania and Ukraine.

[24] None of the changes have been implemented for first order autocorrelation term, oil returns, and residuals of Brent Oil, US and EU markets, respectively in all three specifications.
[25] The trading of European individual markets take place in the same time compared to trading's of US stocks.
[26] The table reports mean specifications both for EU market and Oil market returns

Thus, the sensitivity analysis based on various specifications throughout redundant variable tests draws attention to several brief conclusions. Firstly, by omitting the US one lagged return yield the E.U mean spillover effects to have strong evidences towards stock returns of individual European emerging and developing economies. Judging by obtained signs and scales of coefficients for some countries, the strong indication of EU mean spillovers using redundant variable test seems to be interpreted by previous high correlation (0.828) between the US and EU stock returns. It is worth to note that high correlation between two explanatory variables, namely the US and EU lagged returns, possibly introduce Multicollinearity problem which cannot be ignored (Brook, 2008). Secondly, no any significant changes are reported for mean spillover transmission from oil commodity market. Finally, trading time effect in European markets and thereby using simple EU stock returns at time t, instead of one lagged return is not reasonable main concern which could enable to eliminate the weak indication of mean spillovers effects from EU developed markets.

6.3 Sub-periods empirical results

In order to compare and analyze the feasibility of mean and volatility spillovers performance prior to Global Financial Crisis of 2008, the constant spillover model is examined respectively before and aftermath financial crisis. The first sub-period is chosen from 1st of September 2000 to 29th of August 2008 and the second sub-period overlaps with the sample period from 5th of September 2008 until 30th of March 2012. Table 11 reports the empirical findings for the first sub-period sample. Again, none of the estimated coefficients for first order autocorrelation is significant. The mean spillovers over entire period tend to be low power to drive the stock returns of eight European national markets. More specifically, only Poland and Ukraine are strongly influenced by global US mean spillover effects.

As shown in Table 10, except for Croatia, the regional mean spillover effects from EU market is still negligible. Additionally, the strong evidence from one period lagged oil returns are obtained for stock returns of Romania, Russia, and Ukraine. The effects seem to be highly significant for Russia and the magnitude of the positive coefficient is doubled in first sub-period compared to entire sample estimation. The possible interpretation for differences in signs and positive magnitude of coefficient for Russia can be explained by the fact that oil price has experienced increasing trend over the first sub period (Graph 1). Overall, the higher the oil prices are, it seems the more significantly and positively Russian stock returns are influenced. The result is also due to the fact that, the oil and gas sector account highest proportion market capitalization. In addition, similar to entire estimation period the volatility spillovers from the US, EU and oil market are highly significant in first sub-period. The sign and scale estimated coefficients' are very close to the case of full sample period.

Table 11: The constant spillover model estimation results for individual country j's stock returns over first sub-sample (from Sep 2000 to Oct 2008)

	Croatia	Czech	Hungary	Poland	Romania	Russia	Turkey	Ukraine
c_0	0.541*	0.593*	0.402#	0.354#	0.536*	0.508*	0.290	0.369
	(0.000)	(0.000)	(0.011)	(0.015)	(0.004)	(0.004)	(0.294)	(0.157)
c_1	-0.001	-0.080^	-0.032	-0.084	0.022	-0.030^	-0.087	-0.020
	(0.977)	(0.070)	(0.501)	(0.137)	(0.674)	(0.051)	(0.181)	(0.727)
δ	0.242#	0.004	0.022	-0.117	0.187	0.048	0.217	0.486
	(0.013)	(0.956)	(0.830)	(0.296)	(0.120)	(0.670)	(0.161)	(0.051)
γ	-0.086	0.009	0.863	0.279#	-0.157	0.069	0.049	-0.305#
	(0.348)	(0.183)	(0.375)	(0.013)	(0.255)	(0.577)	(0.780)	(0.036)
φ	0.015	-0.090	0.048	0.091#	0.066	0.180*	0.075	-0.978#
	(0.635)	(0.629)	(0.163)	(0.017)	(0.138)	(0.000)	(0.273)	(0.040)
ψ	0.643*	0.953*	1.025*	1.061*	0.577*	0.705*	1.231*	0.524*
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
θ	0.195*	0.466*	0.582*	0.848*	0.224#	0.613*	1.242*	-0.048
	(0.000)	(0.000)	(0.000)	(0.000)	(0.011)	(0.000)	(0.000)	(0.681)
ϑ	0.075#	0.096*	0.059*	0.119*	0.115*	0.201*	0.197	-0.137#
	(0.027)	(0.000)	(0.000)	(0.000)	(0.008)	(0.000)	(0.000)	(0.017)
ω	2.152#	0.012	3.052	0.441	0.584	0.371^	0.199	0.947*
	(0.031)	(0.424)	(0.023)	(0.144)	(0.134)	(0.095)	(0.410)	(0.002)
α	0.146#	0.001	-0.058	0.101^	0.092#	0.153*	0.133*	0.236*
	(0.011)	(0.854)	(0.171)	(0.057)	(0.022)	(0.006)	(0.001)	(0.000)
α^*	0.008	-0.013*	0.193*	-0.033	-0.039	0.113#	-0.006	0.067
	(0.9185)	(0.004)	(0.002)	(0.539)	(0.239)	(0.039)	(0.197)	(0.287)
β	0.582*	1.003*	0.617*	0.869*	0.889*	0.884*	0.912*	0.767*
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)

Note: P values are in the parentheses and *, #, and ^ represent significance level at 1%, 5% and 10% respectively

Furthermore, the estimation results for second sub-period are summarized in Table 11. First, we observe strong evidences on first-order autocorrelation coefficients for Poland, Romania, and Ukraine. Eventually, the strong evidence of mean spillovers from the regional EU market is evidenced on stock returns of Hungary, Romania, and Ukraine. In contrast, the mean spillovers from US market are negligible. The insignificant results are obtained for one period lagged oil returns. The estimation results can be due the relative small number of observations to capture the mean volatility spillovers in GJR-GARGH model.

As in the whole and first sub-period the all the stock returns of eight national European countries are significantly and strongly influenced by volatility spillovers from energy market and dominant global and regional stock markets. All of the estimated coefficients for volatility spillover effects hold the almost the same signs and increase scale over the entire second sub-period. Quite importantly, the Table 12 shows the magnitude of the positive coefficients from WF Oil, GF US and RF EU substantially increased implying more volatility spillovers have been transmitted to individual countries after of the Global Financial Crisis of 2008. It can be seen from the variance ratios that unexpected returns are increased for all countries after Global Financial Crisis (Table A5-2 in Appendix). In addition to this, the asymmetric terms in conditional variance process have found to be significant for Croatia, Poland, Russia, Turkey and Ukraine.

Table 12: The constant spillover model estimation results for individual country j's stock returns over second sub period sample (from October 2008 to March 2012)

	Croatia	Czech	Hungary	Poland	Romania	Russia	Turkey	Ukraine
c_0	-0.232	-0.270	-0.178	-0.382*	-0.052	-0.082	0.246	-0.296
	(0.186)	(0.193)	(0.474)	(0.005)	(0.821)	(0.731)	(0.271)	(0.299)
c_1	0.095	-0.032	-0.149^	-0.191*	-0.153#	-0.110	-0.049	0.237*
	(0.117)	(0.716)	(0.068)	(0.008)	(0.019)	(0.125)	(0.478)	(0.000)
δ	0.018	-0.007	0.476*	0.180	0.383*	0.049	0.104	0.275*
	(0.839)	(0.606)	(0.002)	(0.157)	(0.001)	(0.716)	(0.421)	(0.005)
γ	-0.001	0.101	-0.151	-0.004	-0.199	-0.058	-0.162	-0.097
	(0.997)	(0.423)	(0.293)	(0.972)	(0.181)	(0.703)	(0.316)	(0.504)
φ	0.007	0.041	-0.070	0.235	0.080	-0.060	-0.043	0.021
	(0.866)	(0.524)	(0.315)	(0.667)	(0.244)	(0.419)	(0.479)	(0.711)
ψ	0.790*	1.273*	1.533*	1.295*	1.086*	0.648*	0.985*	0.198
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.148)
θ	0.634*	1.007*	1.124*	1.063*	0.867*	0.773*	1.106*	0.946*
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
ϑ	0.340*	0.401*	0.506*	0.513*	0.443*	0.784*	0.449*	0.363*
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
ω	0.070#	0.474^	0.955	0.019	0.105^	0.097	0.517*	0.762*
	(0.022)	(0.073)	(0.187)	(0.745)	(0.052)	(0.248)	(0.000)	(0.000)
α	-0.018*	0.202^	0.187	-0.065	-0.017	-0.056*	-0.092*	2.090*
	(0.000)	(0.062)	(0.192)	(0.132)	(0.457)	(0.000)	(0.000)	(0.002)
α*	-0.044*	-0.054	0.151	0.087#	-0.041	0.082*	0.063#	-1.887*
	(0.000)	(0.726)	(0.459)	(0.028)	(0.306)	(0.000)	(0.011)	(0.009)
β	-1.015*	0.757*	0.675*	1.013*	1.016*	1.003*	1.015*	0.086*
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.224)

Note: p-values are in the parentheses and *, #, and ^ represent significance level at 1%, 5% and 10% respectively.

In summary, although, the empirical results for mean spillover effects on first sub-period are very close the results from entire sample, some strong evidences over second sub period are found. The sub-periods empirical findings showed that likewise over entire period from September 2000 to March 2012, the volatility spillovers from oil market and dominant stock markets are found to be significant in first and second sub periods. Besides that, judged by higher value of estimated coefficients in second sub-period the volatility transmissions from aforementioned markets substantially increased compared to those in first sub-period. Additionally, over the second sub-period and some national markets' stock returns seem to respond asymmetrically towards transmitted market shocks. The results from calculated variance ratio also confirms that after the Global Financial Crisis of 2008 prior to second sub-period, the markets volatility spillovers substantially increased and also the local shocks seem to be small compared to first sub-period and entire period model (Table A4:1 and A4:2).

6.4 Asymmetric spillover effects on stock returns

This section provides the empirical results of possible asymmetric responses of individual stock returns specified by equation (19) in econometric methodology section. Although, asymmetric term is associated in primary spillover models and found to be significant for some countries (Hungary and Turkey), the above approach sheds more light on exploring the response of stock returns separately towards negative and positive market shocks and upturns and downturns in lagged returns transmitted respectively global (GF US), regional (RF EU), and world factors (WF Oil). Since the mean specification for global and regional factors are negligible, and in the following paragraphs the asymmetric effects from all transmitted market shocks and only from one lagged oil price returns are reported and analyzed[27].

The Table 13 summarized the estimation results for asymmetric tests on national stock returns. Except for Croatia, all other stock markets respond asymmetrically to upturns and downturns in oil price, where the estimated coefficient of $R^{+}_{oil,t-1}$ and φ_1 is highly significant[28]. The coefficients of $R^{-}_{oil,t-1}$ and φ_0 is found to be significant for Czech, Poland, Romania and Russia. In other words, it seems the increase in oil returns has more effect rather than decrease and the magnitude of increase is greater for countries such as Poland, Czech

[27] In order to save the space the full asymmetric test results effects table including increase and decrease in one period lagged returns of US and EU stock markets are provided in Table A5-1.
[28] Note: the constant one period own lagged of individual countries are not reported in estimation results.

and Russia. The Wald test ($H_0^5: \varphi_0 = \varphi_1$) of no oil shocks, however is strongly rejected only for Romania and Ukraine. Moreover, the regression results in Table 12 also indicates stock markets of all the European emerging and developing countries except for Croatia respond asymmetrically to oil shocks. Although, Romania, Russia and Ukraine seem to respond significantly only for positive shocks, however, the stock returns of Czech, Hungary, Poland, and Turkey are significantly dependent both in decrease and increase in oil commodity oil price. The overall conclusion is that stock returns of individual countries tent to asymmetrically react to oil price market shocks.

Furthermore, some indication of asymmetric existences towards global US and regional EU market shocks are recorded. The strong evidences of asymmetric response for US and EU contemporary residuals specified with negative ($\epsilon_{US,t}^{-}$ and $\epsilon_{EU,t}^{-}$) and positive ($\epsilon_{US,t}^{+}$ and $\epsilon_{EU,t}^{+}$) shocks are obtained. Based on the significant coefficient values, the negative shocks in both US and EU markets have more effects than positive shocks, implying that investors tend to react sharply to the negative shocks rather than positive shocks.

Table 13: Estimated coefficients for the asymmetric spillover model, Sep. 2000 to Mar. 2012

	Croatia	Czech	Hungary	Poland	Romania	Russia	Turkey	Ukraine
φ_0	0.011	-0.054#	0.047	0.072*	0.077#	0.110*	0.049	-0.096
	(0.890)	(0.020)	(0.102)	(0.009)	(0.015)	(0.005)	(0.320)	(0.007)
φ_1	0.013	1.092*	1.239*	1.203*	0.923*	0.701*	1.009*	0.301*
	(0.846)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
ψ_0	0.182	0.780*	0.866*	0.979*	0.605*	0.782*	1.046*	0.280*
	(0.307)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
ψ_1	-0.041	0.179*	0.202*	0.231*	0.227*	0.364*	0.212*	0.069
	(0.795)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.175)
θ_0	-0.044	0.379*	2.589*	0.341#	0.389^	0.499*	0.189#	0.947*
	(0.666)	(0.005)	(0.001)	(0.039)	(0.052)	(0.006)	(0.050)	(0.002)
θ_1	-0.285*	0.125*	0.063	0.115*	0.104*	0.122*	0.029#	0.236*
	(0.007)	(0.000)	(0.215)	(0.003)	(0.000)	(0.002)	(0.038)	(0.000)
ϑ_0	0.009	-0.027	0.161#	-0.005	-0.020	0.001	0.058*	0.067
	(0.874)	(0.468)	(0.025)	(0.893)	(0.454)	(0.998)	(0.001)	(0.287)
ϑ_1	-0.030	0.836*	0.619*	0.853*	0.887*	0.849*	0.936*	0.767*
	(0.715)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)

Note: P-values are in the parentheses and *,#, and ^ represent significance level at 1%, 5% and 10% respectively

Despite the fact that regression coefficients yield to be appeared strongly for contemporary residuals from oil market as well as the US and EU stock markets, the joined Wald tests are not rejected in most of the cases. More specifically, in case of regional EU shocks the joined Wald tests of no asymmetric responses to EU shocks are rejected only for Hungary, Poland, and Russia at 5% significance level. Unsurprisingly, asymmetric responses towards negative shocks are more substantial thank positive shocks caused by regional EU residuals in case of Hungary, Poland, and Russia. In addition, the Russia is only market to respond significantly to oil price shocks, yet at 10% significance level. Moreover, the asymmetric shocks from US market are reported to be jointly significant only in case of Croatia and Romania. Taking into account, empirical findings from Wald test results some evidences of asymmetric effects can be concluded (Table A5-2 in Appendix). However, in most of the cases the stock returns of the European emerging and developing markets do not react asymmetrically to either contemporary residuals or returns.

6.5 Conditional spillover model results

In order to evaluate performance of spillover intensities caused by global and regional stock market, conditional spillover model introduced by Ng (2000) and specified by equations (20)-(23) are relevantly explored for eight individual European countries. With the aim of investigation of behavior of EU and US mean and return spillovers, two instrumental variables, namely exchange rates and total trade to GDP ratio is applied.

The results shown on Table 14 indicates that the only significant variable explaining the EU conditional spillover effects for Croatia is total trade to GDP ratio with positive coefficient (0.973). The similar arbitrary empirical results are obtained for case of Czech and Romania. More specifically, in the case of Czech, US conditional mean spillovers and EU volatility spillovers are significantly driven by exchange rate changes, respectively with coefficients of -0.630 and 1.122.

On the other hand, for Romania, the US conditional mean spillover effect is explained by total trade/GDP ratio with corresponding positive coefficient of 0.159. Moreover, both US conditional mean and volatility spillovers are not found to be strong in case of Hungary and Poland. The exchange rate change is also strong proxy in explaining the behavior of EU conditional volatility transmissions for Poland, while the total trade/GDP is strong proxy in the case of Hungary. For both Hungary and Poland, conditional mean spillovers from regional markets are reported to be significantly introduced by two macroeconomic instrumental variables.

Table 14*:* Estimated coefficients for the conditional spillover model, from Sep 2010 to Mar 2012

		CRO	CZE	HUN	POL	ROM	RUS	TUR	UKR
		US conditional Mean spillover							
Constant	v_0	2.555	-1.668	5.520	1.140	4.446	-4.982	0.835	-6.972^
		(0.352)	(0.724)	(0.196)	(0.819)	(0.156)	(0.140)	(0.750)	(0.077)
Exchange rate changes	v_1	-0.774	-0.630#	-0.497	-0.097	1.199	2.916*	1.782*	1.683#
		(0.108)	(0.036)	(0.324)	(0.872)	(0.080)	(0.004)	(0.000)	(0.023)
Trade to GDP ratio	v_2	0.084	0.353	0.241	0.071	0.159#	0.450*	0.119	-0.340
		(0.728)	(0.405)	(0.483)	(0.772)	(0.044)	(0.003)	(0.635)	(0.136)
		EU conditional Mean spillover							
Constant	p_0	-0.061	4.037	-33.459#	3.606	0.039	1.847	0.305	-3.212
		(0.962)	(0.648)	(0.019)	(0.523)	(0.993)	(0.794)	(0.936)	(0.452)
Exchange rate changes	p_1	4.239	-0.921	4.656#	3.563*	1.447	0.210	1.026*	0.839
		(0.529)	(0.366)	(0.024)	(0.003)	(0.140)	(0.884)	(0.004)	(0.186)
Trade to GDP ratio	p_2	0.973#	0.084	0.982	0.132	0.215	0.291	0.063	-0.207
		(0.021)	(0.937)	(0.136)	(0.840)	(0.655)	(0.277)	(0.880)	(0.586)
		US conditional Volatility spillover							
Constant	w_0	2.094	-0.951	3.781	1.180	3.783	-6.278^	1.239	-8.485#
		(0.456)	(0.846)	(0.384)	(0.813)	(0.233)	(0.064)	(0.648)	(0.029)
Exchange rate changes	w_1	-0.659	-0.540^	-0.338	0.115	1.264^	3.206*	1.735*	1.933*
		(0.180)	(0.079)	(0.514)	(0.854)	(0.067)	(0.001)	(0.000)	(0.008)
Trade to GDP ratio	w_2	0.067	-0.256	0.165	0.101	0.539^	0.424*	0.161	-0.426^
		(0.787)	(0.565)	(0.636)	(0.827)	(0.076)	(0.000)	(0.537)	(0.060)
		EU conditional Volatility spillover							
Constant	q_0	-6.200	-6.962	-13.691	-3.805#	-2.621	4.682*	-0.817	-1.010
		(0.389)	(0.131)	(0.123)	(0.021)	(0.311)	(0.002)	(0.733)	(0.674)
Exchange Rate Changes	q_1	2.696	1.122#	1.319	1.316#	0.178	-1.060	-0.407#	-0.172
		(0.479)	(0.046)	(0.341)	(0.043)	(0.747)	(0.239)	(0.045)	(0.656)
Trade to GDP ratio	q_2	-0.104	0.401	-0.800#	-0.231	-0.319	0.112	-0.114	-0.153
		(0.627)	(0.483)	(0.020)	(0.510)	(0.228)	(0.476)	(0.633)	(0.442)

Note: P-values are in the parentheses and *,#, and ^ represent significance level at 1%, 5% and 10% respectively

More interesting is still the case of Russia, both EU conditional mean and volatility spillovers are not found to be driven by constructed instruments. However, the estimated instruments for explaining the parameters of US conditional mean and volatility spillover effects are found to be highly significant and positive. There is strong empirical evidence that US conditional spillover intensities can be explained by exchange rate fluctuations of USD and Ruble as well as total trade between US and Russia. When it comes to findings for Turkey only exchange rate changes, namely LIRA/USD and LIRA/EURO can significantly impact the US and EU conditional spillover parameters. Finally, none of the time varying spillover models can be explained by exchange rate changes and total trade to GDP ratio in the case of Ukraine. The insignificant evidences for Ukraine, draws attention to explore other macroeconomic or financial data to further empirical investigation of conditional spillover effects.

The overall overview is that instrumental variables, namely exchange rate changes and Trade/GDP ratios do not properly introduce clear cut results for all the countries to explain conditional spillover models. It should be noted, however, among the obtained empirical results for instrumental intensities exchange rate changes seem to me more powerful instrument in explaining the US and EU spillover parameters rather than trade/GDP ratio.

Finally, in order to fully evaluate the conditional model variance ratios are also computed. The Table 15 shows that similar to constant model volatility spillover effects local shocks account for most of the market shocks on total variance, and the US variance ratios are still substantial compared to the EU and Oil ratios (Table 17).

Table 15: Summary statistics for Variance ratios for conditional spillover mode over entire period, (from Sep 2000 to March 2012)

		CRO	CZE	HUN	POL	ROM	RUS	TUR	UKR
VR EU	Mean	21.117	24.469	23.240	20.168	16.716	9.456	12.122	8.553
	Std.dev	0.249	0.266	0.256	0.232	0.214	0.143	0.182	0.160
VR US	Mean	16.118	26.541	24.913	27.777	17.745	21.047	25.102	10.136
	Std.dev	0.205	0.252	0.257	0.275	0.207	0.239	0.279	0.182
VR OIL	Mean	8.458	8.183	7.137	7.967	9.154	17.169	6.142	2.076
	Std.dev	0.149	0.140	0.116	0.124	0.157	0.218	0.118	0.065
VR OWN	Mean	54.246	40.665	44.708	44.093	56.383	52.035	56.633	79.230
	Std.dev	0.345	0.319	0.322	0.322	0.335	0.335	0.242	0.286

All in all, similar to constant spillover model, the volatility spillovers effects from the US market shocks account most of the variances compared to regional EU stock market and oil market in conditional model. However, in contrast to constant spillover model, the regional and global volatility spillovers are almost equally distributed for Czech, Hungary, Romania, Poland, and Ukraine. Eventually, the own shocks are strongly appeared to be in Ukraine which then followed by Turkey, and Croatia.

6.6 AR (1)-GJR-GARCH (1, 1) dummy model: EU enlargement effect

Bearing the question in mind, whether EU enlargement does influence spillover, this section presents the empirical findings prior to European Union enlargement effect on stock returns. By using equation (24) given by GARCH model the effect of EU accession is empirically examined for EU member countries, namely Czech, Hungary, Poland, and Romania. Table 16 shows that the significant result is obtained only in case of Romania, when the country joined EU. More specifically, the finding indicates that the membership of Romania into EU in 2007 seems to be statistically significant, still with negative coefficient of -0.555. In other words, in the case of Romania volatility spillovers seem to decrease after the EU accession. However, the results of EU enlargement effect do not in 2004 are significant. Additionally, quantified variance ratios for GARCH dummy model also revealed that the proportion of variance caused by regional EU effect is relevantly small for Romania, which is 9.3%.[29]

Table 16[30]: Dummy variable model estimation results

	Czech	Hungary	Poland	Romania
c_0	0.583*	0.591#	0.147	0.629*
	(0.000)	(0.013)	(0.497)	(0.001)
c_1	-0.073^	-0.064	-0.106#	-0.031
	(0.085)	(0.139)	(0.021)	(0.466)
δ	-0.032	0.121	-0.029	0.184#
	(0.642)	(0.127)	(0.714)	(0.047)
γ	0.173#	0.083	-0.235*	-0.110
	(0.012)	(0.293)	(0.005)	(0.276)
ϑ	0.057#	0.050^	0.072	0.082#
	(0.017)	(0.079)	(0.009)	(0.010)
Φ	1.083*	1.240*	1.205*	0.903*
	(0.000)	(0.000)	(0.000)	(0.000)
Φ_{Dum}	*-0.328*	*-0.455*	*0.078*	*-0.555#*
	(0.119)	(0.112)	(0.753)	(0.050)
θ	0.774*	0.871*	0.979*	0.608*
	(0.000)	(0.000)	(0.000)	(0.000)
φ	0.182*	0.206*	0.231*	0.228*
	(0.000)	(0.000)	(0.000)	(0.000)

Note: P values are in the parentheses and *,#, and ^ represent significance level at 1%, 5% and 10% respectively

[29] The measured variance ratios are presented Table A4-3 in Appendix.
[30] The Table 16 presents results only for mean equation in GJR-GARCH model.

7. Conclusion

The paper studied the mean and volatility spillover effects from U.S, and E.U stock markets as well as from the oil market to eight individual European stock markets. Applying GJR-GARCH model, I found strong evidences of volatility transmission namely, global, regional and world factors towards the national stock markets of eight European countries. The empirical outcomes also showed amongst the three external factors, the US volatility spillover intensities account for most of the proportion of unexpected returns, except for Croatia and Romania. The empirical findings are also similar for pure global and regional stock markets while excluding the world factor oil. The empirical results of mean spillover effects are mixed and imply no strong evidences for Croatia, Hungary, and Turkey. In addition, through various specifications in so-called sensitivity analysis, I have revealed that the E.U mean spillover effects are fairly sensitive in conjunction with US mean spillover effects towards individual stock markets countries. Moreover, the results also showed that for none European Union member countries are highly influenced by their own local shocks which appeared to be highest in Ukraine followed by Turkey, and Croatia. Moreover, judging by sign and scale of estimated coefficients as well as quantified variance ratios volatility transmissions from all three sources substantially increased in second sub period, which is estimated aftermath of Global Financial Crisis of 2008.

Furthermore, oil market shocks are found to be significant for all countries and, in particular, drive the stock returns of Russia with very high and positive coefficients. This finding is readily explained by the higher presence of oil and gas sector companies in total the market capitalization for Russian stock market. On the other hand, there are weak indications of asymmetric responses. More specifically, only Romania, Poland, and Ukraine asymmetrically respond to EU market shocks. Asymmetric responses towards US shocks are found only in the case of Romania. Only the stock returns of Russia, yet weakly, respond asymmetrically to oil price market shocks.

Additionally, in order to test the effect European Union enlargement effect through spillover effects on stock markets, I utilized the presence of a dummy variable constant model. I have found that the effect is evident only in the case of Romania. Thus, the overall inference of the dummy model is that EU membership matters for stock returns in Romania while being significant and still negative. Although the significance level is not statistically high, it can reflect some evidence of hypothesis on EU enlargement effect.

Finally, I also found statistically significant results for a conditional model and the conditional model have appeared to be prior to the constant spillover model. Overall, the empirical outcomes on conditional spillover model can be summarized based on two essential inferences. The first inference is related to estimation results on parameters of global and regional markets. More specifically, the empirical findings of exchange rate changes in most cased are highly significant and positive for U.S spillover effects, while judged by sign and scale of coefficients for the E.U spillover effects the empirical results are found to be relatively weak or insignificant. The second implication is that that most of the parameters both for mean and spillover effects are significantly explained by exchange rate changes rather than the total trade/GDP ratio, which shows the relative importance of exchange rate fluctuations for spillover effects amongst examined European countries.

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Appendix

Table A1: GDP growth rate and FDI selected European countries, 2001-2011

	2001	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**Average**
GDP growth (%)												
Croatia	5,73	4,15	4,65	5,51	6,75	6,36	6,56	6,40	6,20	-5,50	0,20	4,27
Czech	3,65	2,46	1,90	3,60	4,48	6,32	6,81	6,13	2,46	-4,15	2,35	3,27
Hungary	4,23	3,71	4,51	3,85	4,80	3,96	3,90	0,11	0,89	-6,80	1,26	2,22
Poland	4,26	1,21	1,44	3,87	5,34	3,62	6,23	6,79	5,13	1,61	3,94	3,95
Romania	2,10	5,70	5,10	5,20	8,40	4,17	7,90	6,00	9,43	-8,50	0,95	4,22
Russia	10,00	5,09	4,74	7,30	7,18	6,38	8,15	8,54	5,25	-7,81	4,03	5,35
Turkey	6,77	-5,70	6,16	5,27	9,36	8,40	6,89	4,67	0,66	-4,83	9,01	4,24
Ukraine	5,90	9,20	5,20	9,40	12,10	2,70	7,30	7,90	2,30	-14,80	4,20	4,67
FDI, net inflows (% GDP)												
Croatia	6,71	4,21	5,98	2,64	3,93	6,94	8,63	9,02	5,10	0,67	1,92	5,07
Czech	8,75	10,83	2,25	4,38	8,97	3,66	5,76	2,86	1,48	3,44	2,19	4,96
Hungary	7,44	4,47	2,47	4,19	6,93	6,07	2,84	4,11	1,19	1,36	0,74	3,80
Poland	2,98	2,08	2,12	5,07	3,38	5,66	5,53	2,81	3,03	1,95	2,67	3,39
Romania	2,26	2,49	3,67	8,45	6,51	9,20	5,95	6,85	3,00	1,81	1,42	4,69
Russia	0,90	1,01	2,04	2,55	1,89	3,07	4,40	4,56	3,07	2,90	2,87	2,66
Turkey	1,61	0,46	0,54	0,71	1,98	3,78	3,57	2,66	1,41	1,20	2,04	1,81
Ukraine	2,08	1,63	2,84	2,64	9,06	5,20	6,93	6,06	4,11	4,71	3,75	4,46

Note: Source, Data Stream

Table A2: The correlation among stock returns data

	SOFIX	CROBEX	PX	BUX	WSE20	BET	MICEX	PFTS	ISE 100	Brent Oil	MSCI EU	S&P 500
SOFIX	1											
CROBEX	0,049	1										
PX	-0,003	0,533	1									
BUX	0,007	0,541	0,786	1								
WSE 20	0,003	0,479	0,756	0,76	1							
BET	0,006	0,513	0,599	0,541	0,51	1						
MICEX	0,056	0,367	0,626	0,615	0,615	0,416	1					
PFTS SE	0,036	0,236	0,209	0,203	0,212	0,251	0,227	1				
ISEl 100	-0,052	0,306	0,524	0,536	0,513	0,339	0,462	0,415	1			
Brent OIL	0,115	0,215	0,226	0,216	0,231	0,203	0,353	0,081	0,129	1		
MSCI EU	-0,035	0,588	0,741	0,725	0,71	0,524	0,583	0,178	0,506	0,186	1	
S&P 500	-0,032	0,437	0,563	0,565	0,57	0,403	0,503	0,141	0,425	0,114	0,828	1

Table A3-1: The constant symmetrical spillover model estimation results for individual country j's stock returns over full sample period (September 2000- March 2012)

	Croatia	Czech	Hungary	Poland	Romania	Russia	Turkey	Ukraine
c_0	0.313*	0.336*	0.349*	0.203^	0.337#	0.349#	0.295	0.268
	(0.006)	(0.002)	(0.009)	(0.071)	(0.017)	(0.012)	(0.123)	(0.184)
c_1	0.066	-0.071^	-0.063	-0.101#	-0.024	-0.078	-0.078	0.113#
	(0.155)	(0.093)	(0.143)	(0.020)	(0.579)	(0.135)	(0.135)	(0.020)
δ	0.113^	-0.032	0.119	-0.030	0.193#	0.095	0.095	0.474*
	(0.099)	(0.645)	(0.137)	(0.702)	(0.034)	(0.411)	(0.411)	(0.000)
γ	-0.015	0.168#	0.082	0.235^	-0.120	0.007	0.007	-0.275#
	(0.814)	(0.014)	(0.296)	(0.100)	(0.229)	(0.954)	(0.154)	(0.023)
φ	0.022	0.055#	0.047	0.072^	0.077#	0.026*	0.025	-0.094*
	(0.313)	(0.018)	(0.106)	(0.010)	(0.016)	(0.606)	(0.606)	(0.010)
ψ	0.771*	1.084*	1.258*	1.203*	0.918*	0.702*	1.001*	0.292*
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)
θ	0.435*	0.771*	0.882*	0.975*	0.601*	0.782*	1.068*	0.290*
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
ϑ	0.136*	0.178*	0.205*	0.231*	0.227*	0.364*	0.217*	0.076
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.126)
ω	1.652	0.406	3.053	0.343#	0.402#	0.499	0.180#	0.971
	(0.001)	(0.004)	(0.001)	(0.038)	(0.049)	(0.005)	(0.127)	(0.002)
α	0.210*	0.110*	0.181*	0.112*	0.093*	0.123*	0.075*	0.271*
	(0.000)	(0.000)	(0.001)	(0.000)	(0.000)	(0.002)	(0.000)	(0.000)
β	0.611*	0.833*	0.547*	0.854*	0.882*	0.849*	0.925*	0.763*
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)

Note: P-values are in the parentheses and *,#, and ^ represent significance level at 1%, 5% and 10% respectively

Table A3-2: Wald tests for first sub period from 01st Sep 2000 to 29th of August 2008.

	$Wald_1$	$Wald_2$	$Wald_3$	$Wald_4$	$Wald_5$
Croatia	7.1108*	30.395*	2.523^	3.073#	24.017*
	(0.000)	(0.000)	(0.081)	(0.027)	(0.000)
Czech	50.036*	89.909*	6.887*	1.072	100.05*
	(0.000)	(0.000)	(0.001)	(0.361)	(0.000)
Hungary	30.928*	59.306*	2.3777^	1.0487	65.473*
	(0.000)	(0.000)	(0.094)	(0.349)	(0.000)
Poland	69.147*	54.753*	8.849*	3.655	87.667*
	(0.000)	(0.000)	(0.000)	(0.013)	(0.000)
Romania	4.1115*	13.622*	4.316*	1.9939*	13.825*
	(0.0171)	(0.000)	(0.014)	(0.114)	(0.014)
Russia	23.915*	21.389*	19.091*	5.898*	37.784*
	(0.000)	(0.000)	(0.000)	(0.001)	(0.000)
Turkey	46.676*	29.460*	4.895*	1.3435	52.881*
	(0.000)	(0.000)	(0.007)	(0.259)	(0.000)
Ukraine	2.2012	21.954*	5.454*	6.1912*	9.3016*
	(0.112)	(0.000)	(0.004)	(0.000)	(0.000)

Note: P values are in the parentheses The joined Wald tests are examined under the following null hypotheses.

$H_0^1: \varphi_j = \vartheta_j = 0$ (No Oil prices spillover effects on stock returns)
$H_0^2: \gamma_j = \theta_j = 0$ (No Global US spillover effects on stock returns)
$H_0^3: \delta_j = \psi_j = 0$ (No Regional EU spillover effects on stock returns)
$H_0^4: \varphi_j = \delta_j = \gamma_j = 0$ (No mean spillover effects on stock returns)
$H_0^5: \vartheta_j = \theta_j = \psi_j = 0$ (No volatility spillover effects on stock returns)

Table A3-3: Wald tests on constant spillover model for second sub-period from 09th September 2008 to 30th of March 2012.

	$Wald_1$	$Wald_2$	$Wald_3$	$Wald_4$	$Wald_5$
Croatia	71.527*	30.189*	19.984*	0.050	124.15*
	(0.000)	(0.000)	(0.000)	(0.985)	(0.000)
Czech	130.28*	63.745*	31.055*	0.385	167.77*
	(0.000)	(0.000)	(0.000)	(0.763)	(0.000)
Hungary	170.61*	81.729*	38.111*	3.910*	320.32*
	(0.000)	(0.000)	(0.000)	(0.001)	(0.000)
Poland	98.723*	84.661*	53.586*	1.385	210.96*
	(0.000)	(0.000)	(0.000)	(0.249)	(0.000)
Romania	42.054*	48.586*	30.156*	5.143#	92.779*
	(0.000)	(0.000)	(0.000)	(0.020)	(0.000)
Russia	36.697*	9.9446*	71.828*	0.2991	96.375*
	(0.000)	(0.000)	(0.000)	(0.826)	(0.000)
Turkey	96.147*	31.812*	29.318*	0.712	104.318*
	(0.000)	(0.000)	(0.000)	(0.546)	(0.000)
Ukraine	75.744	4.5339#	18.389*	0.2758	84.695*
	(0.112)	(0.000)	(0.004)	(0.106)	(0.000)

Note: P values are in the parentheses and all null hypothesis are as in Table A3:2

Table A4-1: Summary statistics for variance ratios for first sub period from September 2000 to August 2008.

		CRO	CZE	HUN	POL	ROM	RUS	TUR	UKR
VR EU	Mean[31]	18.856	28.776	25.155	19.178	12.995	11.530	14.426	10.822
	Std.dev	0.242	0.274	0.279	0.229	0.196	0.171	0.202	0.181
VR US	Mean	19.862	16.733	19.106	25.535	6.399	17.774	23.525	3.316
	Std.dev	0.207	0.207	0.231	0.272	0.130	0.231	0.257	0.180
VR OIL	Mean	3.641	4.492	1.315	3.759	6.586	9.377	5.107	8.111
	Std.dev	0.076	0.088	0.028	0.082	0.122	0.147	0.106	0.162
VR OWN	Mean	57.639	49.793	54.386	51.526	74.018	61.318	56.940	80.734
	Std.dev	0.347	0.337	0.336	0.332	0.296	0.323	0.333	0.259

Table A4-2: Summary statistics for variance ratios for second sub period from September 2008 to March 2012

		CRO	CZE	HUN	POL	ROM	RUS	TUR	UKR
VR EU	Mean	20.331	26.310	26.055	23.712	20.543	9.881	15.173	1.462
	Std.dev	0.234	0.268	0.264	0.246	0.236	0.148	0.196	0.042
VR US	Mean	21.857	29.998	24.174	28.500	21.913	18.505	28.816	26.867
	Std.dev	0.227	0.277	0.248	0.274	0.242	0.214	0.279	0.289
VR OIL	Mean	11.209	15.220	15.723	17.347	17.518	35.022	16.730	13.717
	Std.dev	0.143	0.190	0.197	0.209	0.220	0.300	0.216	0.162
VR OWN	Mean	39.426	28.471	34.047	29.566	40.030	36.429	39.279	57.952
	Std.dev	0.321	0.271	0.279	0.267	0.312	0.304	0.316	0.334

Table A4-3: Summary statistics for variance ratios for dummy variable model period from September 2000 to March 2012.

		CZE	HUN	POL	ROM
VR EU	Mean	18.566	15.005	23.105	9.335
	Std.dev	0.229	0.199	0.250	0.118
VR US	Mean	29.469	28.400	27.536	20.385
	Std.dev	0.272	0.235	0.275	0.246
VR OIL	Mean	9.221	8.593	7.593	11.492
	Std.dev	0.138	0.136	0.122	0.164
VR OWN	Mean	42.742	48.000	41.764	58.787
	Std.dev	0.316	0.332	0.318	0.317

[31] Means are given in terms of percentage (%).

Table A5-1: Asymmetric test results on stock returns of country j, Sep 2000 to March 2012

	Croatia	Czech	Hungary	Poland	Romania	Russia	Turkey	Ukraine
δ_0	0.083	0.336*	0.282#	0.207^	0.359#	0.349#	0.215	0.236
	(0.517)	(0.001)	(0.039)	(0.081)	(0.018)	(0.020)	(0.250)	(0.267)
δ_1	-0.081	-0.070^	-0.062	-0.100#	-0.025	-0.074	-0.081	0.105#
	(0.558)	(0.098)	(0.148)	(0.020)	(0.551)	(0.061)	(0.104)	(0.032)
γ_0	0.010	-0.031	0.116	-0.031	0.196#	-0.004	0.103	0.464*
	(0.952)	(0.658)	(0.141)	(0.698)	(0.034)	(0.958)	(0.386)	(0.000)
γ_1	-0.058	-0.166#	0.807	-0.236*	-0.121	0.066	-0.002	-0.274#
	(0.688)	(0.015)	(0.307)	(0.004)	(0.234)	(0.528)	(0.987)	(0.023)
φ_0	0.011	-0.054#	0.047	0.072*	0.077#	0.110*	0.049	-0.096
	(0.890)	(0.020)	(0.102)	(0.009)	(0.015)	(0.005)	(0.320)	(0.007)
φ_1	0.013	1.092*	1.239*	1.203*	0.923*	0.701*	1.009*	0.301*
	(0.846)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
ψ_0	0.182	0.780*	0.866*	0.979*	0.605*	0.782*	1.046*	0.280*
	(0.307)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
ψ_1	-0.041	0.179*	0.202*	0.231*	0.227*	0.364*	0.212*	0.069
	(0.795)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.175)
θ_0	-0.044	0.379*	2.589*	0.341#	0.389^	0.499*	0.189#	0.947*
	(0.666)	(0.005)	(0.001)	(0.039)	(0.052)	(0.006)	(0.050)	(0.002)
θ_1	-0.285*	0.125*	0.063	0.115*	0.104*	0.122*	0.029#	0.236*
	(0.007)	(0.000)	(0.215)	(0.003)	(0.000)	(0.002)	(0.038)	(0.000)
ϑ_0	0.009	-0.027	0.161#	-0.005	-0.020	0.001	0.058*	0.06
	(0.874)	(0.468)	(0.025)	(0.893)	(0.454)	(0.998)	(0.001)	(0.287)
ϑ_1	-0.030	0.836*	0.619*	0.853*	0.887*	0.849*	0.936*	0.767*
	(0.715)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)

Note: P-values are in the parentheses and *,#, and ^ represent significance level at 1%, 5% and 10% respectively.

Table A5-2: Wald test results for spillover effects in asymmetric model from September 2000 to March 2012.

	$Wald_1$	$Wald_2$	$Wald_3$	$Wald_4$	$Wald_5$	$Wald_6$
CRO	2.936^	1.618	0.681	1.089	4.857	1.309
	(0.087)	(0.203)	(0.794)	(0.297)	(0.057)	(0.252)
CZE	0.023	1.175	0.108	1.402	0.065	0.377
	(0.878)	(0.278)	(0.741)	(0.236)	(0.798)	(0.539)
HUN	0.386	0.383	0.493	5.439#	0.038	0.001
	(0.584)	(0.536)	(0.482)	(0.020)	(0.845)	(0.986)
POL	0.665	0.012	0.266	4.679#	0.554	1.429
	(0.415)	(0.910)	(0.606)	(0.030)	(0.456)	(0.232)
ROM	1.318	0.002	3.120^	2.204	7.358*	0.446
	(0.251)	(0.962)	(0.077)	(0.138)	(0.006)	(0.504)
RUS	0.318	0.057	0.001	3.741#	0.001	5.561^
	(0.572)	(0.810)	(0.991)	(0.050)	(0.981)	(0.090)
TUR	0.104	0.808	0.409	0.432	0.001	1.607
	(0.746)	(0.369)	(0.522)	(0.511)	(0.996)	(0.205)
UKR	1.701	0.402	2.515	17.300*	1.317	0.650
	(0.192)	(0.526)	(0.078)	(0.000)	(0.251)	(0.420)

Note: P-values are in the parentheses and *,#, and ^ represent significance level at 1%, 5% and 10% respectively, and also null hypotheses of joined Wald tests are presented below;

$H_0^1: \delta_0 = \delta_1$: no asymmetric responses to EU lagged returns
$H_0^2: \gamma_0 = \gamma_1$: no asymmetric responses to US lagged returns
$H_0^3: \varphi_0 = \varphi_1$: no asymmetric responses to oil price lagged returns
$H_0^4: \psi_0 = \psi_1$: no asymmetric responses to EU shocks
$H_0^5: \theta_0 = \theta_1$: no asymmetric responses to US shocks
$H_0^6: \vartheta_0 = \vartheta_1$: no asymmetric responses to oil price shocks

Table A6-1: The constant spillover model estimation results by exclusion oil effect for individual country j's stock returns over full sample period (September 2000- March 2012)

	US	EU	CRO	CZE	HUN	POL	ROM	RUS	TUR	UKR
c_0	0.067	0.118^	0.286#	0.373*	0.294#	0.233^	0.401#	0.491*	0.280	0.195
	(0.436)	(0.086)	(0.016)	(0.001)	(0.039)	(0.069)	(0.009)	(0.003)	(0.135)	(0.366)
c_1	-0.058^	-0.088#	0.080	-0.039	-0.048	-0.070	-0.002	-0.031	-0.080^	0.099#
	(0.077)	(0.207)	(0.094)	(0.396)	(0.272)	(0.113)	(0.970)	(0.431)	(0.097)	(0.047)
γ		0.083^	-0.010	-0.164#	0.107	0.243*	-0.124	0.099	0.032	-0.266*
		(0.094)	(0.881)	(0.028)	(0.184)	(0.004)	(0.213)	(0.338)	(0.814)	(0.005)
θ		0.978*	0.437*	0.778*	0.859*	0.979*	0.624*	0.780*	1.081*	0.273*
		(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
δ			0.132^	0.008	0.128	-0.015	0.244#	0.064	0.138	0.392*
			(0.066)	(0.907)	(0.122)	(0.846)	(0.050)	(0.471)	(0.226)	(0.000)
ψ			0.757*	1.077*	1.207*	1.199*	0.933*	0.694*	1.081*	0.361*
			(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
ω	0.423	0.237	1.821	0.453	2.371	0.433#	0.429^	0.580	0.199#	1.027
	(0.000)	(0.006)	(0.001)	(0.004)	(0.002)	(0.018)	(0.080)	(0.014)	(0.045)	(0.001)
α	-0.020	0.154*	0.184*	0.118*	0.043	0.069*	0.090*	0.136*	0.031^	0.213*
	(0.550)	(0.001)	(0.001)	(0.001)	(0.344)	(0.023)	(0.001)	(0.003)	(0.056)	(0.000)
α^*	0.362*	0.017	0.076	-0.021	0.157#	0.024	-0.019	-0.039	0.054#	0.078
	(0.000)	(0.713)	(0.298)	(0.562)	(0.016)	(0.487)	(0.425)	(0.368)	(0.042)	(0.154)
β	0.768*	0.770*	0.590*	0.834*	0.674*	0.876*	0.894*	0.856*	0.936*	0.777*
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)

Note: P values are in the parentheses and *,#, and ^ represent significance level at 1%, 5% and 10% respectively

Table A6-2: Wald test results for spillover effects under oil exclusion constant spillover model (September 2000- March2012)

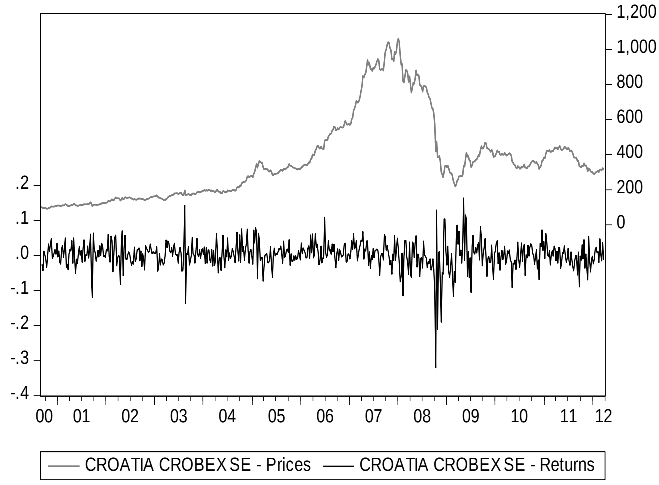
	$Wald_1$	$Wald_2$	$Wald_3$	$Wald_4$
CRO	52.562*	69.398	3.547	121.11
	(0.000)	(0.000)	(0.029)	(0.000)
CZE	206.07	190.57	7.259	379.82
	(0.000)	(0.000)	(0.002)	(0.000)
HUN	201.93	163.76	6.395	570.30
	(0.000)	(0.000)	(0.002)	(0.000)
POL	238.27	131.83	9.873	376.69
	(0.000)	(0.000)	(0.001)	(0.000)
ROM	61.385	87.802	4.851	171.67
	(0.000)	(0.000)	(0.009)	(0.000)
RUS	103.73	29.021	4.158	138.54
	(0.000)	(0.000)	(0.021)	(0.000)
TUR	74.022	39.093	2.236	108.87
	(0.000)	(0.000)	(0.108)	(0.000)
UKR	15.426	24.110	10.048	42.931
	(0.000)	(0.000)	(0.001)	(0.000)

Note: P-values are in the parentheses and *,#, and ^ represent significance level at 1%, 5% and 10% respectively, and also null hypotheses of joined Wald tests are presented below;

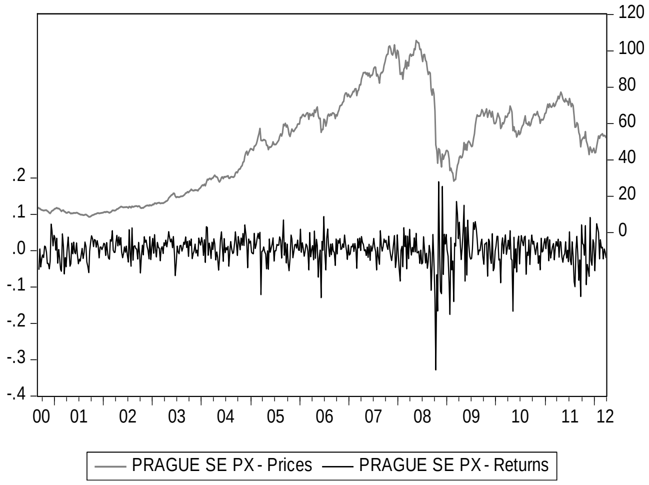
$H_0^1: \gamma_j = \theta_j$: no global US spillover effects
$H_0^2: \delta_j = \psi_j$: no regional EU spillover effects
$H_0^3: \gamma_j = \delta_j$: no mean spillover effects
$H_0^4: \theta_j = \psi_j$: no asymmetric responses to US shocks

Figures A1: Indexes and returns

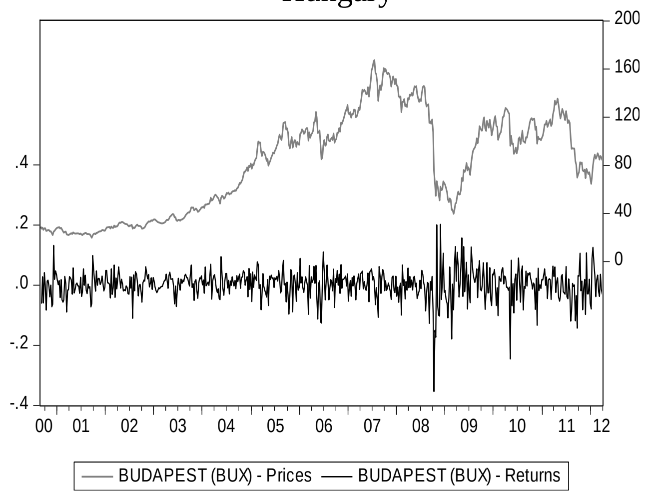
Croatia



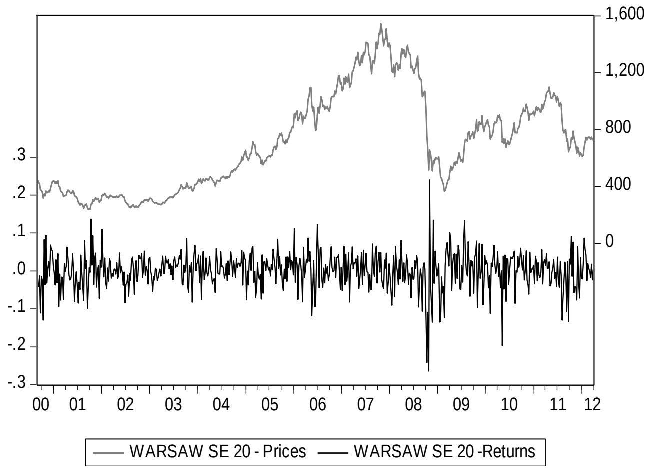
Czech



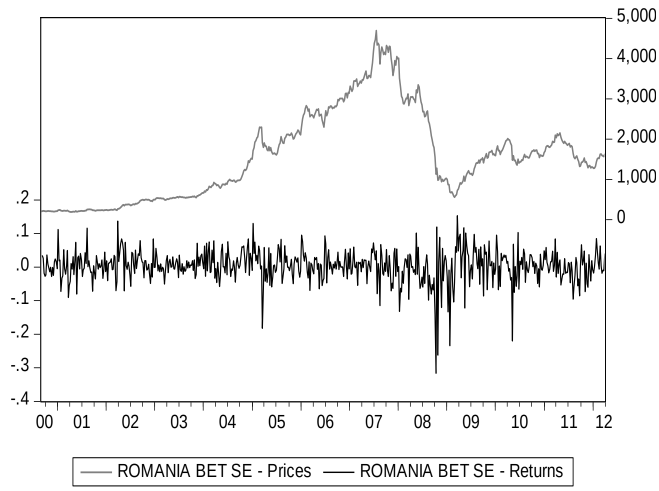
Hungary



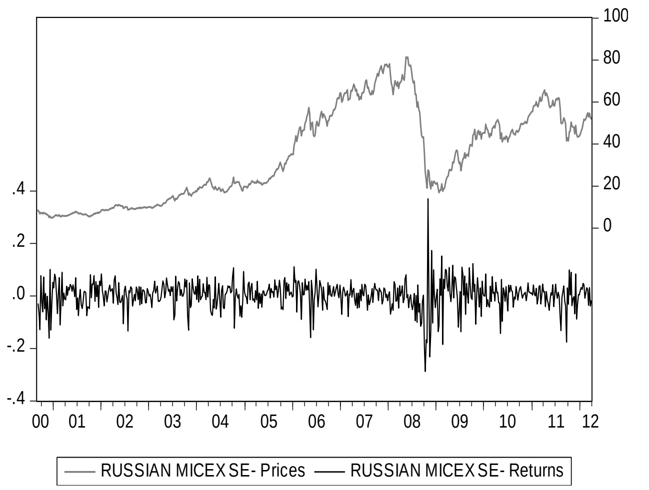
Poland



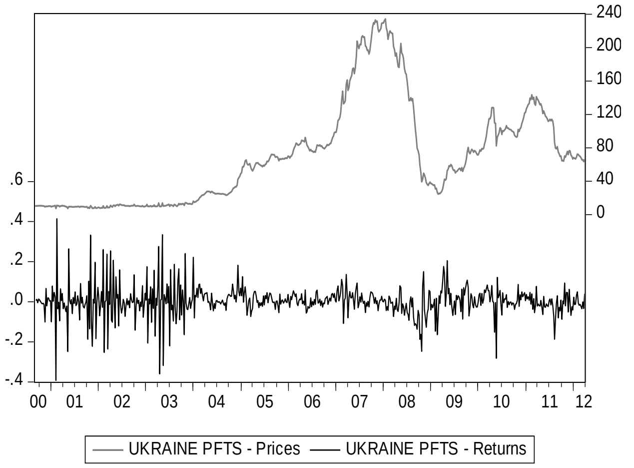
Romania



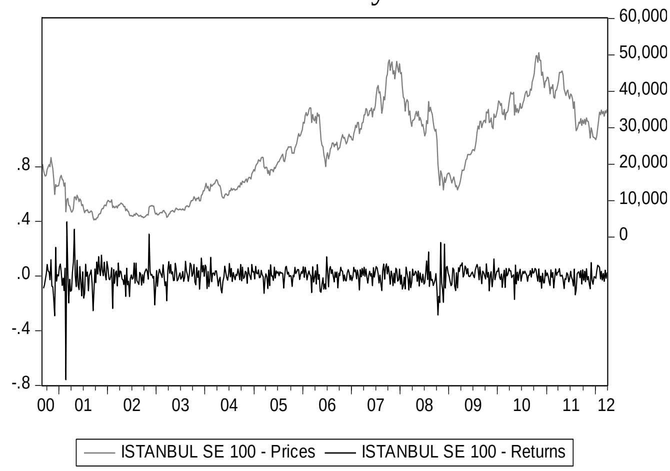
Russia



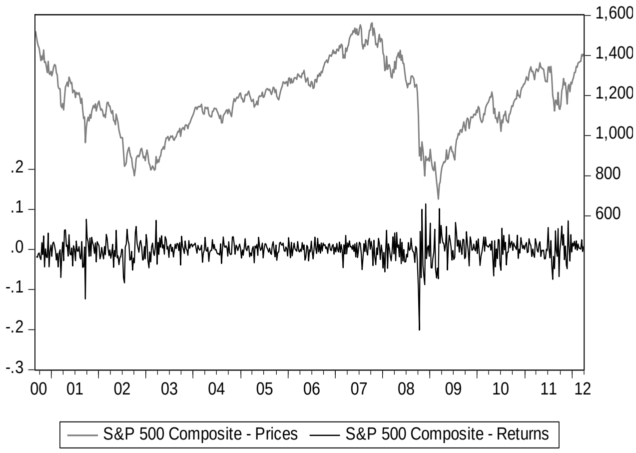
Ukraine



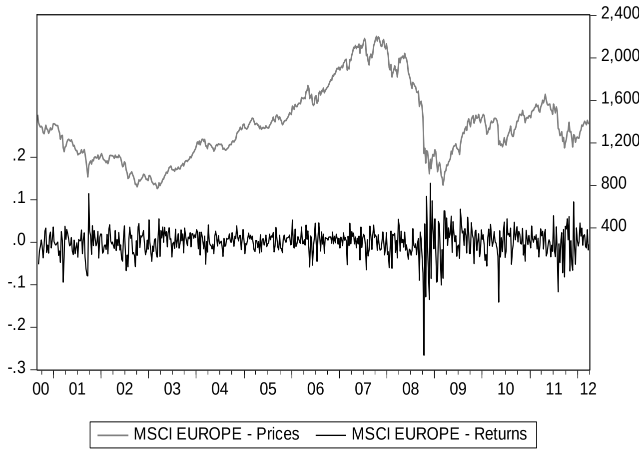
Turkey



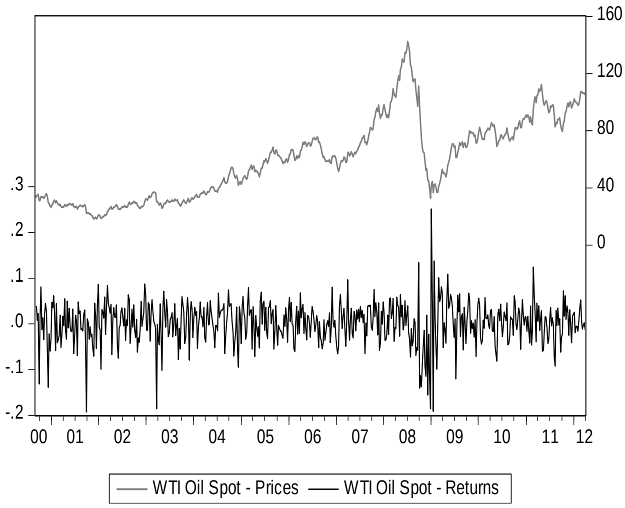
USA



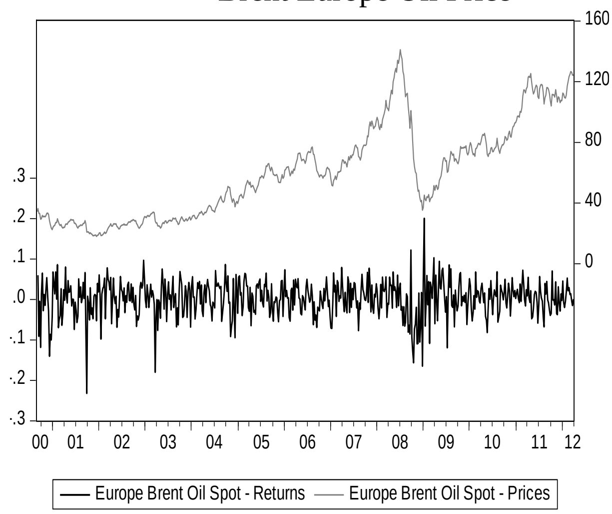
EUROPE



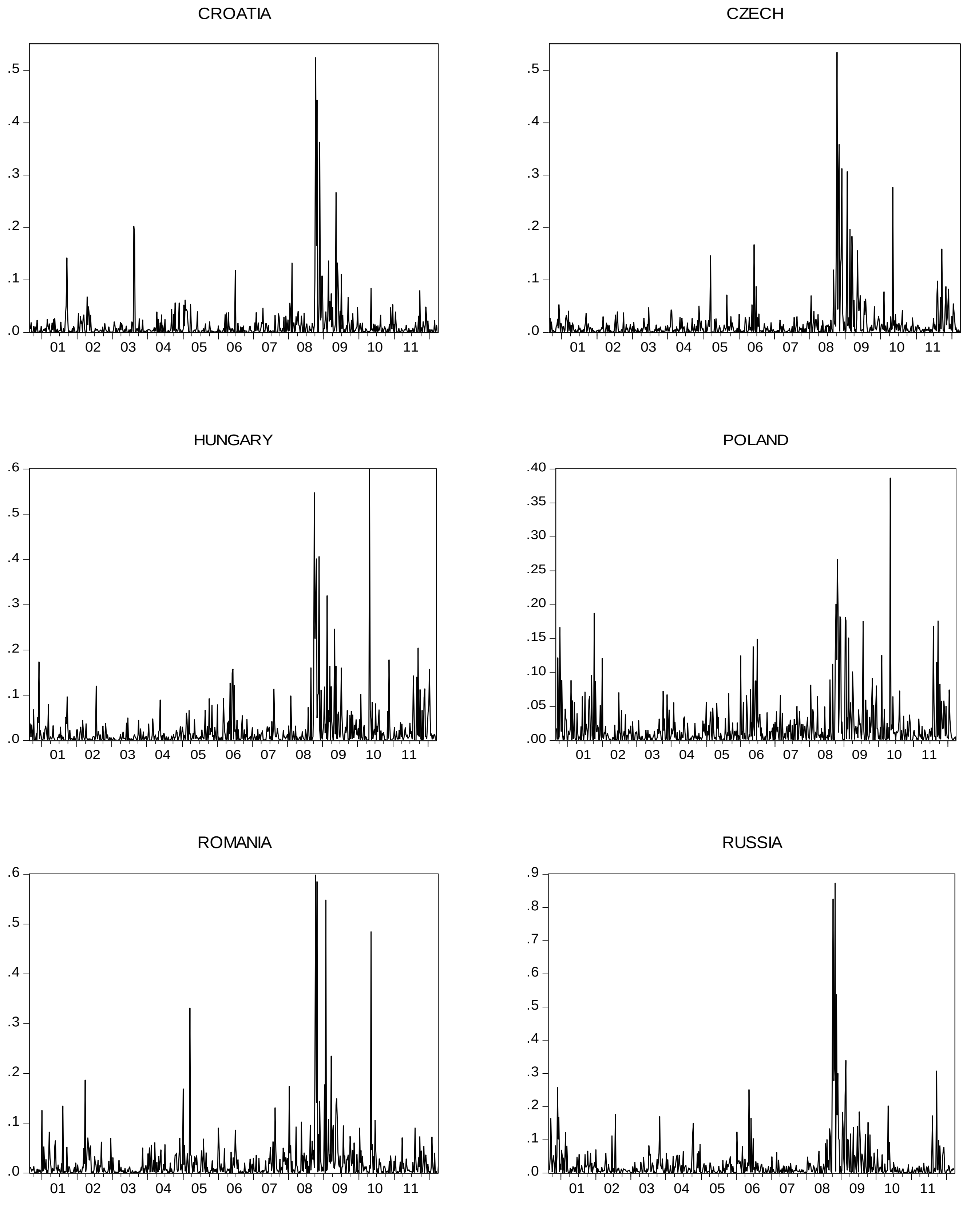
WTI Oil Price



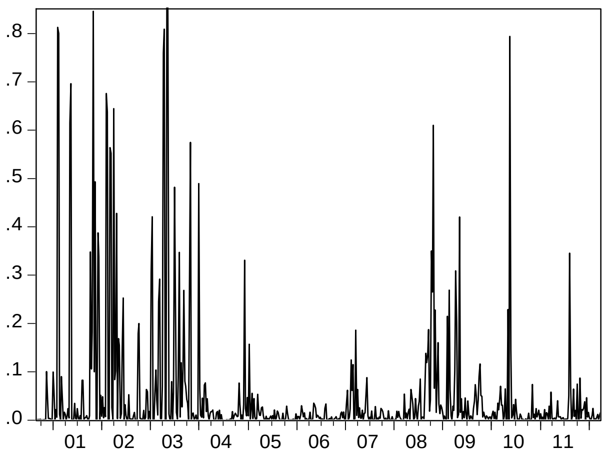
Brent Europe Oil Price



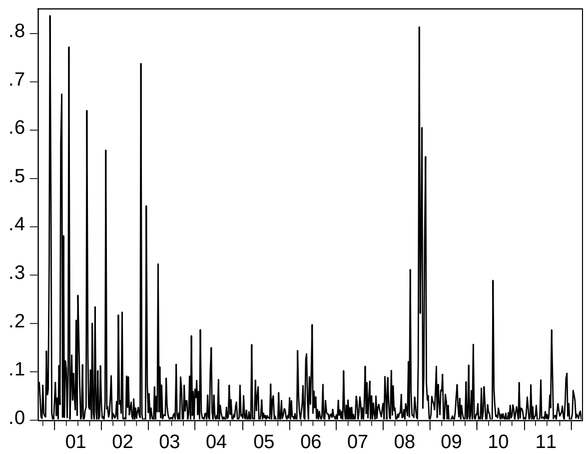
Figures A2: Squared returns



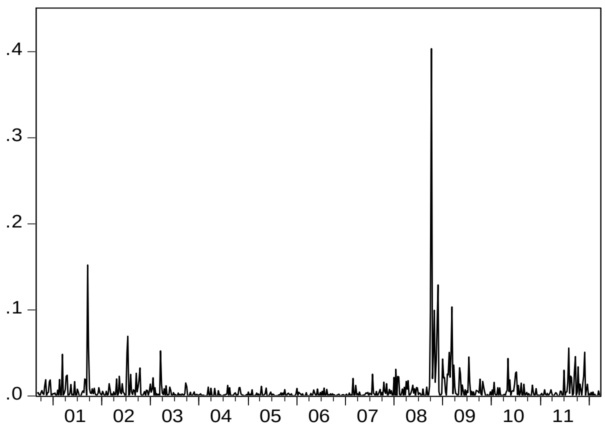
UKRAINE



TURKEY



US



EU

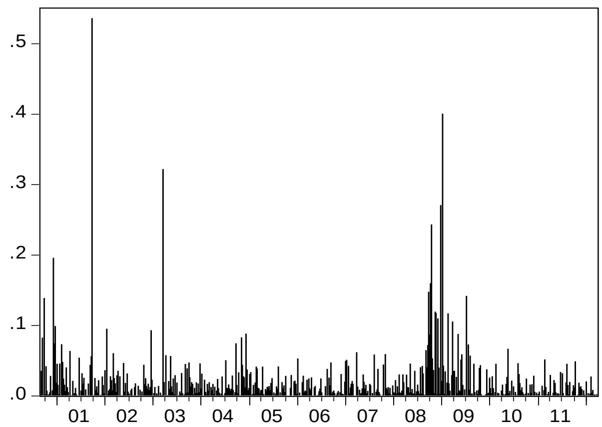


Figure A3: Variance Rratios for constant Spillover models over entire sample period from September 2000 to March 2012 (in Percentage)

Figure A3-1: Croatia

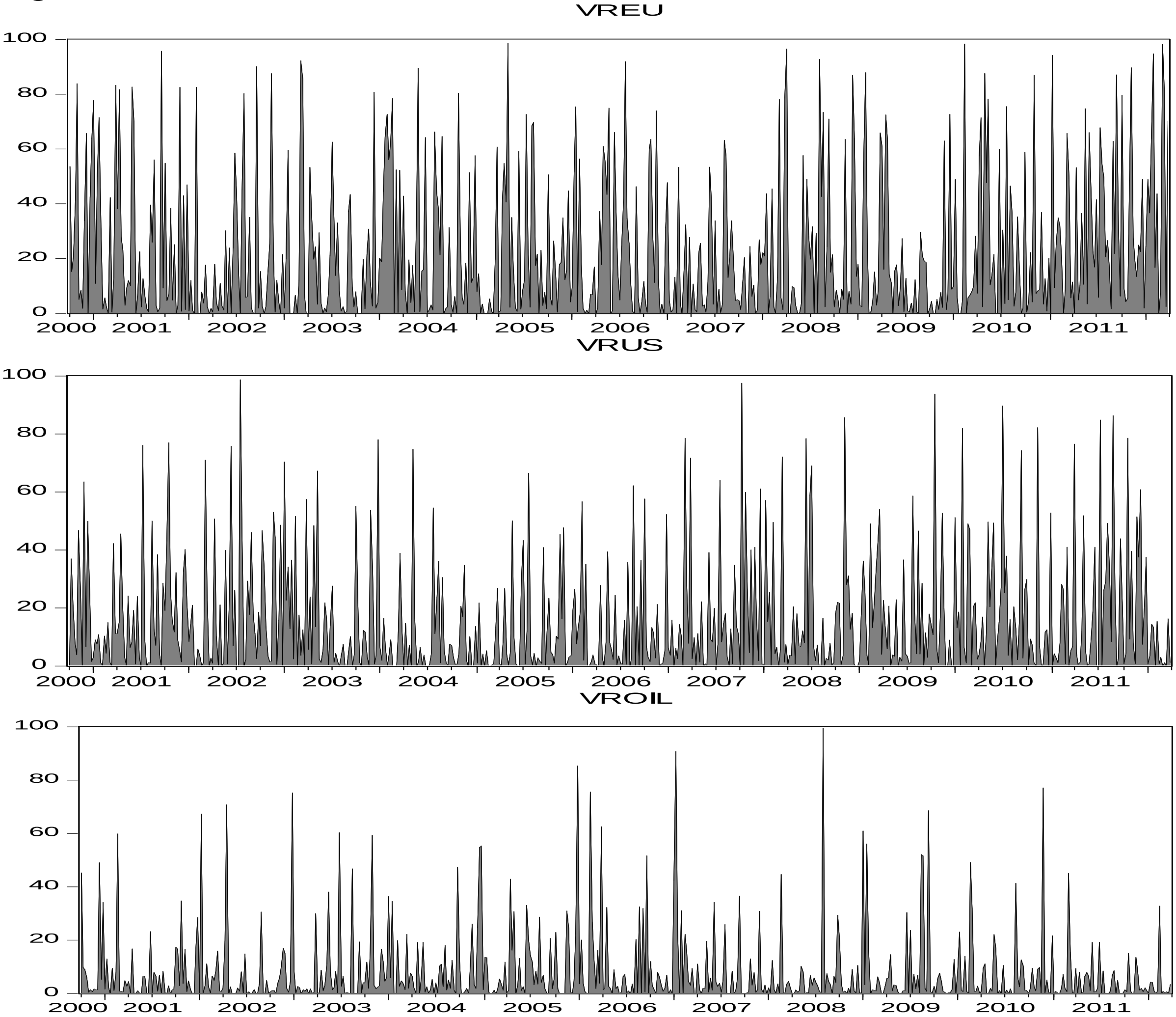
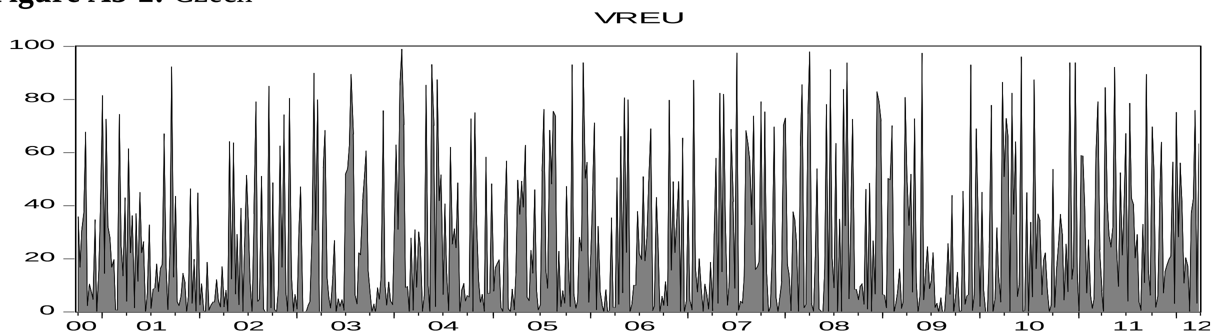


Figure A3-2: Czech



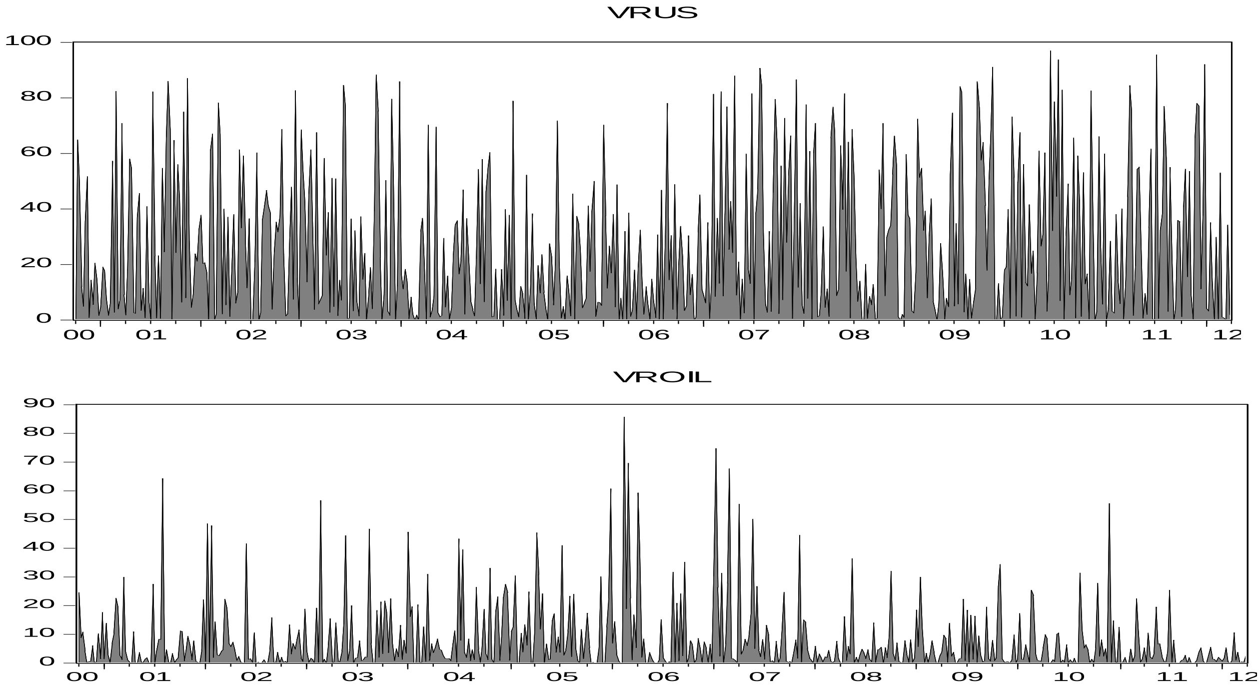


Figure A3-3: Hungary

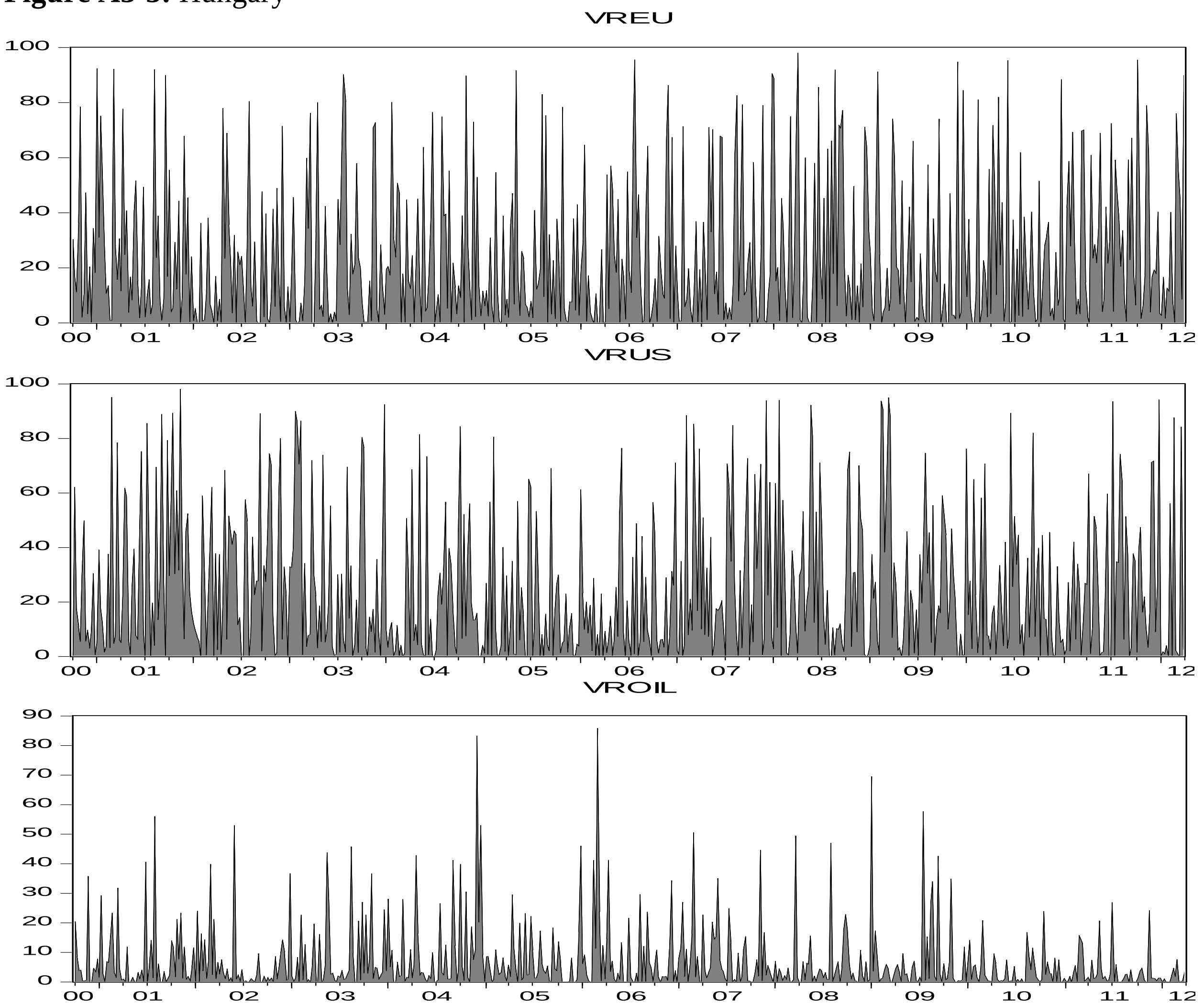


Figure A3-4: Poland

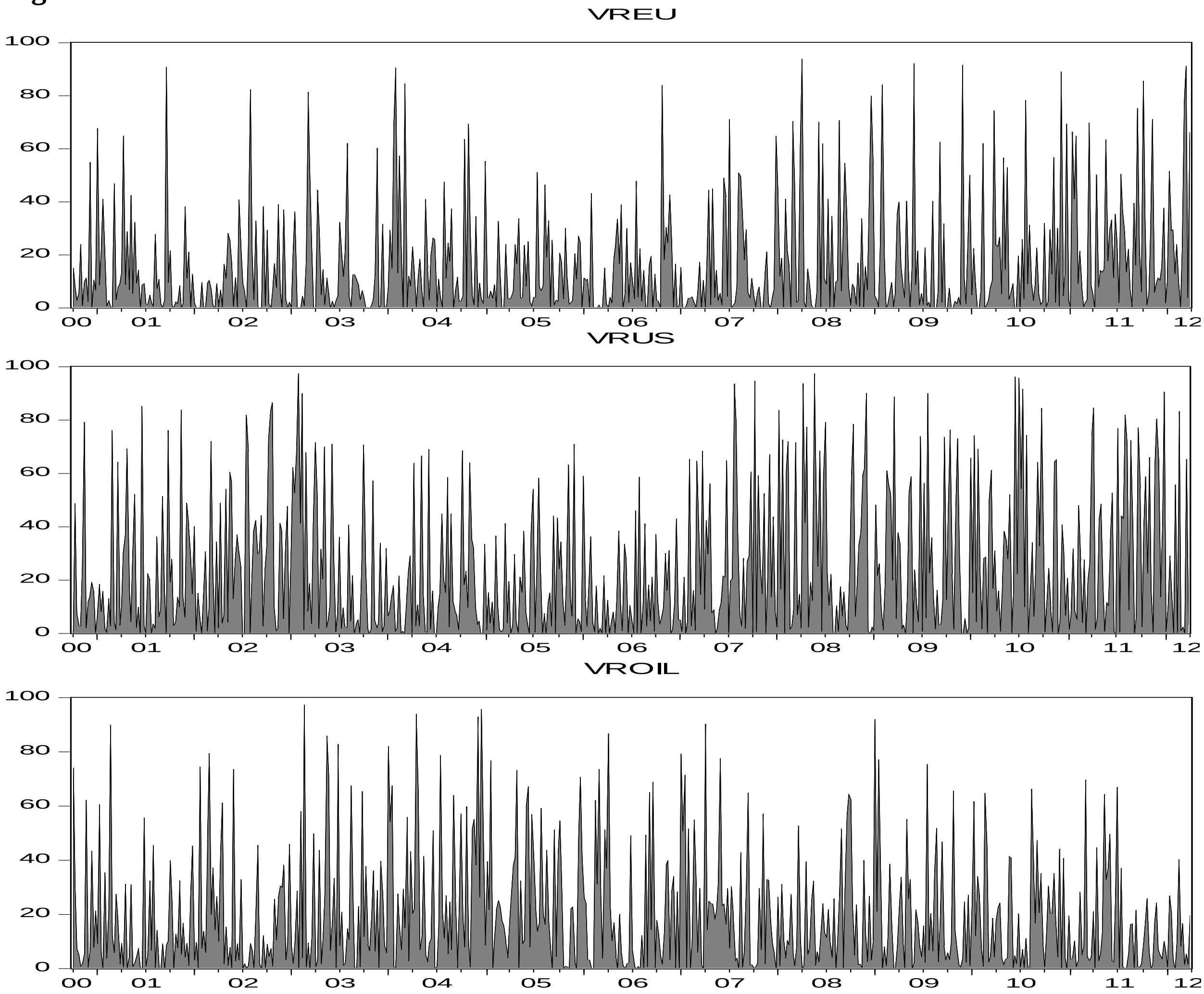
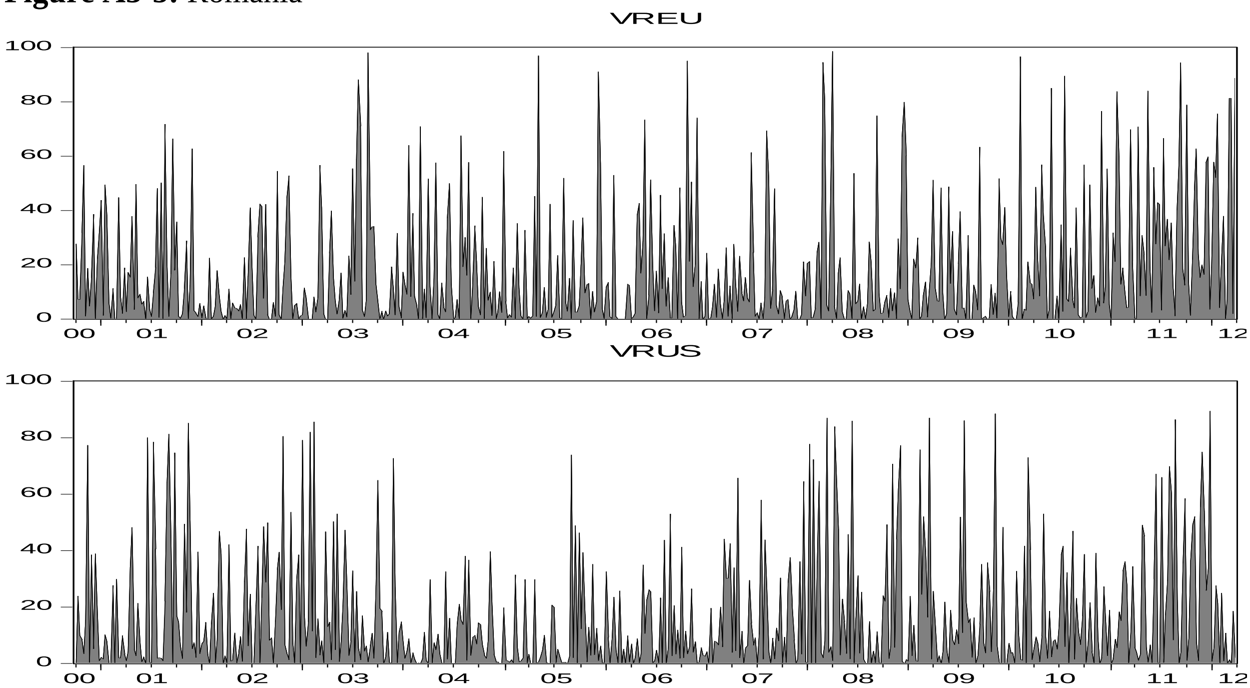


Figure A3-5: Romania



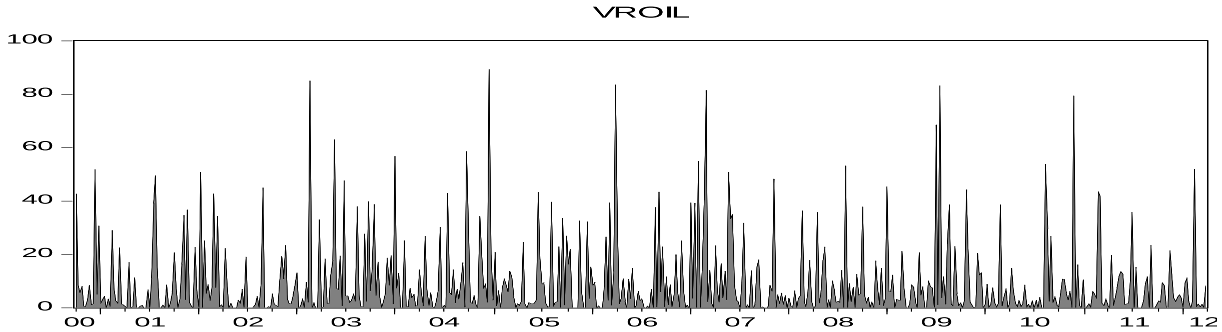
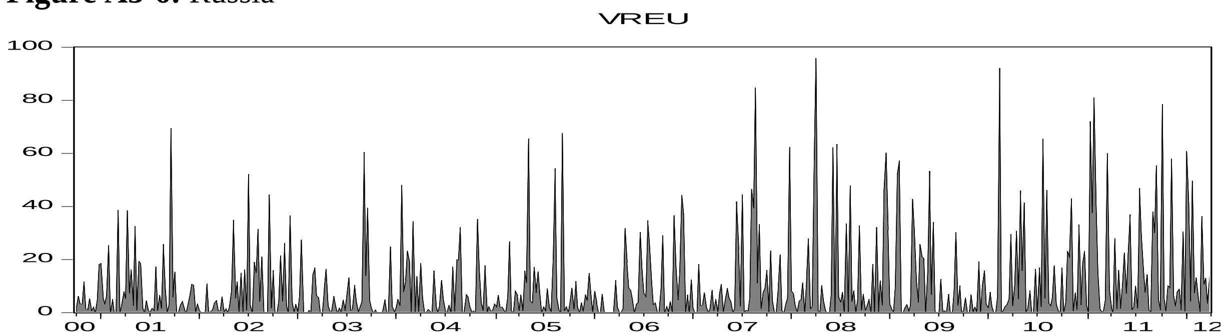
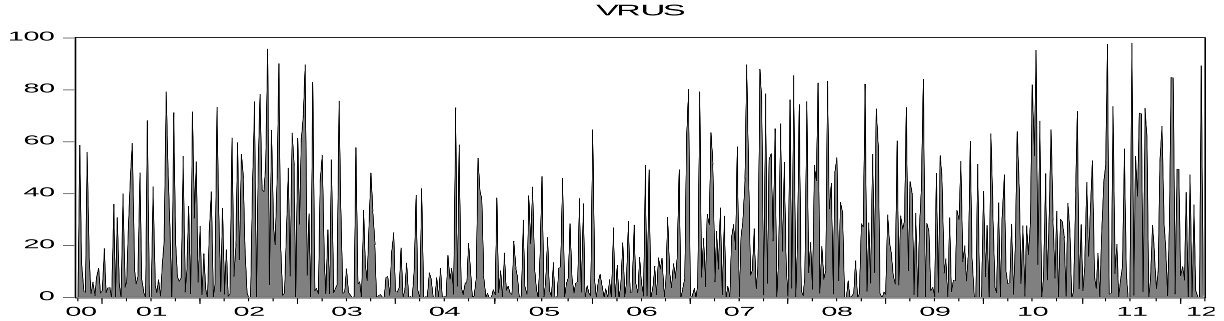


Figure A3-6: Russia





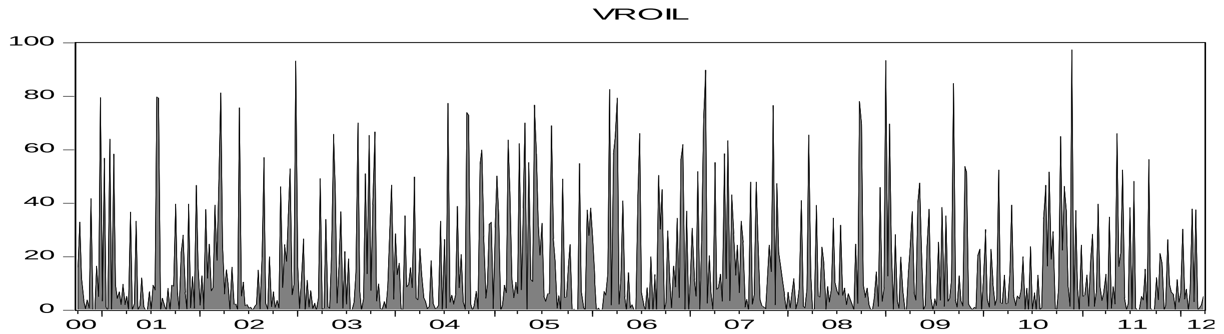
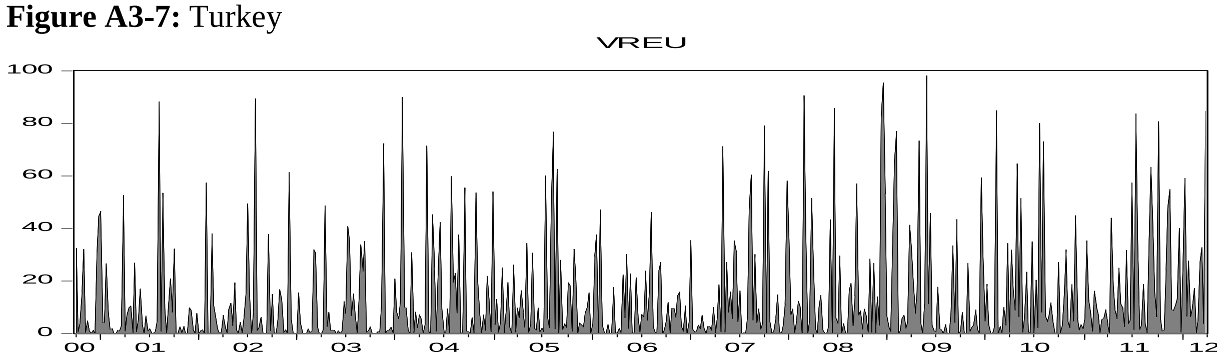


Figure A3-7: Turkey



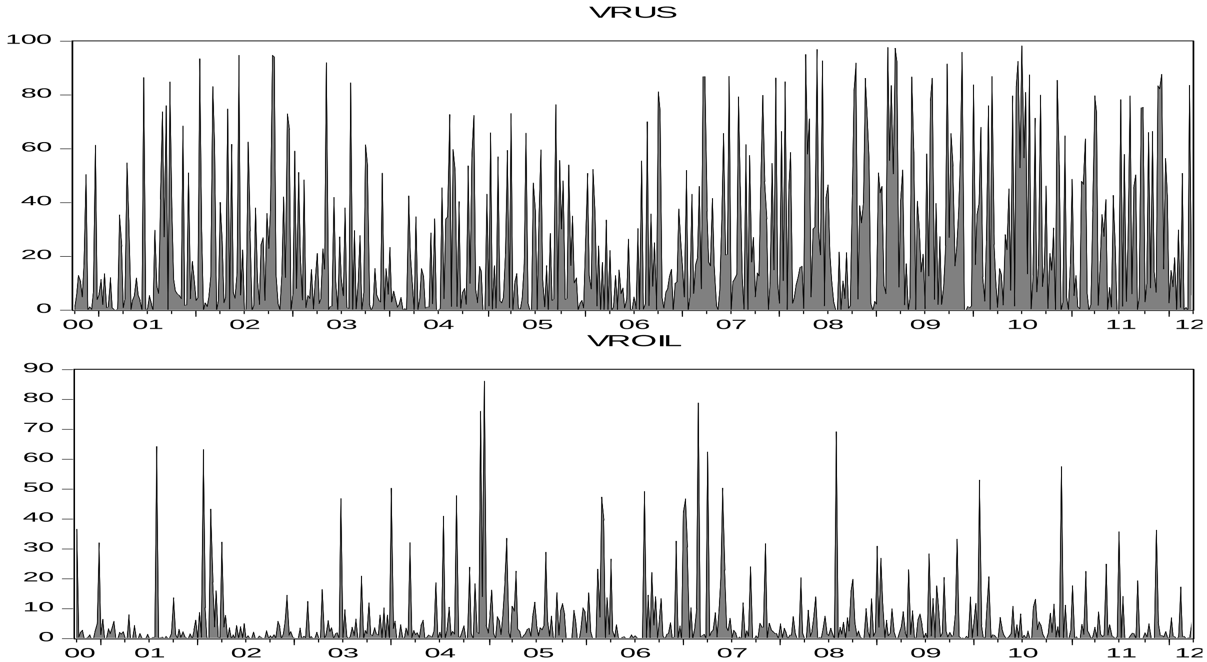


Figure A3-8: Ukraine