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ORIGINALNI NAUČNI RAD

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Prelivanje volatilnosti (nestabilnosti) između najznačajnijih evropskih tržišta kapitala prije i poslije finansijske krize 2008–2009.

Transmission of volatilities among major European equity markets before and after 2008-09 financial crisis

Rezime

Rad istražuje postojanost volatilnosti (nestabilnosti) i njeno prelivanje prije i nakon finansijske krize 2008–2009. korištenjem ETF-a (Exchange traded funds) na najznačajnijim evropskim tržištima kapitala: Francuska, Njemačka, Italija, Španija i Velika Britanija. GARCH (1,1) i EGARCH (1, 1) primijenjeni su na dnevne izvještaje ETF-a pojedinih zemalja u periodu od 30. avgusta 2002. do 31. decembra 2007. i od 31. decembra 2009. do 31. decembra 2015. Rezultati pokazuju da je u evrozoni volatilnost snažno reagovala na tržišna kretanja i taj šok je polako izblijedio u evrozoni. Također, volatilnost se preliva između tržišta kapitala iz uzoraka posmatranih tržišta u periodu nakon krize. Prije krize, jedino se volatilnost britanskog tržišta prelivala na sva ostala tržišta.

Ključne riječi: *postojanost volatilnosti, prelivanje volatilnosti, GARCH, EGARCH.*

Abstract

This paper investigates volatility persistence and transmission of volatilities before and after the 2008-09 crisis using exchange traded funds (ETFs) in the major European equity markets: France, Germany, Italy, Spain and UK. GARCH (1, 1) and EGARCH (1, 1) are applied to daily returns on country ETFs from August 30, 2002 to August 31, 2007 and December 31, 2009 to December 31, 2015. The results show that volatilities react strongly to market movements and their shocks fade away slowly in Eurozone. Furthermore, volatility spills over among the sample equity markets in the post crisis period. In the pre-crisis period, only UK market volatility spills over to other markets.

Keywords: *volatility persistence, volatility spillovers, GARCH, EGARCH.*

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UVOD

Ovaj rad istražuje postojanost volatilnosti i prelivanje volatilnosti na glavnim evropskim tržištima kapitala: Francuska, Njemačka, Italija, Španija i Velika Britanija. Izbor je napravljen na osnovu bliskih ekonomskih odnosa (trgovina i finansije) na osnovu uzorka zemlje sa ciljem da se istražuju tržišta volatilnosti tokom perioda od pet godina prije finansijske krize 2008–2009. godine i šest godina nakon krize. Jedan od razloga za izbor bio je da se proučavaju tržišna kretanja između jačih zemalja EU (Francuska, Njemačka i Velika Britanija), i slabijih zemalja (Italija i Španija) prije i poslije finansijske krize. Istraživanje se nastavlja na prethodni rad koautora na istu temu, ali sa različitim tržištima i proširenom metodologijom.

Finansijska kriza od 2007. do 2009. godine vjerovatno je bila prva prava velika globalna kriza od Velike depresije, koja je trajala od 1929. do 1932. godine. Dok je kriza inicijalno imala svoje porijeklo u Sjedinjenim Američkim Državama u relativno malom segmentu tržišta kreditiranja, kao i na tržištu hipotekarnih kredita, ona se brzo širila na gotovo sve razvijene ekonomije, kao i one u razvoju i na cijeli ekonomski sektor. Kriza je uticala na sva tržišta kapitala u svijetu, mnoge zemlje su doživjele još oštrije slomove tržišta kapitala nego SAD (Bekaert et al., 2014, str. 1).

Podaci se dijele u dva odvojena perioda: pet godina prije finansijske krize 2008. (od 30. avgusta 2002. godine do 31. avgusta 2007. godine) i šest godina nakon krize (31. decembar 2009. do 31. decembra 2015). Period poslije krize je do 31. decembra 2015. godine, uglavnom da bi se izbjegle špekulacije o Brexitu, i od 31. decembra 2009. godine, što predstavlja buran period u Evropi.

Glavni motiv u ovom radu je da se ispita volatilnost veza između glavnih evropskih tržišta kapitala pomoću zemalja ETF-a, na osnovu MSCI indeksa, sa glavnim ciljem doprinosa literaturi o različitim periodima volatilnosti koja se manifestovala u periodu finansijske krize 2007–2009. na različitim tržištima kapitala.

1. PREGLED LITERATURE

Akademska istraživanja postojanja volatilnosti i prelivanja volatilnosti povećala su se od 2007. do 2009. godine, u periodu finansijske krize. Xiao i Dhesi (Xiao, Dhesi, 2010) ispitali su efekte prelivanja volatilnosti i testirali su vremenski promjenljivu korelaciju na četiri berzanska indeksa, CAC, DAX, FTSE100 i S&P500, koji obuhvata period od 5. januara 2004. do 1. oktobra 2009. godine. Oni smatraju da efekti prelivanja volatilnosti postoje na poprilično širokoj osnovi između evropskih i američkih berzi. Zanimljivo je to što oni smatraju da je berza Velike Britanije glavni prenosnik volatilnosti unutar evropskih berzi, dok su SAD jedan od glavnih izvoznika u svijetu. Samarakoon (Samarakoon, 2011) ispituje prenos šokova nestabilnosti između SAD i stranih tržišta. On je otkrio važnost dvosmijernosti, asimetričnosti, međuzavisnosti i zaraze na tržištima u razvoju, sa značajnim regionalnim varijacijama.

Jiang (Jiang at al., 2012) ispituje efekte američkih i evropskih medijskih najava o prelivanjima volatilnosti širom američkih i evropskih berzi. Oni pružaju dokaze o značajnim implicitnim prelivanjima volatilnosti između američkih i evropskih tržišta i širom evropskih tržišta. Njihovi rezultati su izdržali test ekstremnih tržišnih dešavanja, kao što su nedavne finansijske krize, i pružaju dokaze o zaraznoj volatilnosti kroz posmatrana tržišta. Kenourgios, D., i Padhi (Kenourgios, Padhi, 2012) istražuju finansijske zaraze na tri tržišta u razvoju krajem 1990-ih, kao i tokom krize 2007. godine, sa fokusom na finansijska tržišta zemalja u razvoju i SAD, kao dva globalna pokazatelja. Oni smatraju da berze predstavljaju snažnije prenosne mehanizme tokom trajanja tri zarazne krize.

Slimane (Slimane, 2013) istražuje različite modele dinamike povezivanja između berzi Francuske, Njemačke i Velike Britanije tokom globalne finansijske krize, analizirajući dinamiku veza između ovih tržišta u mirnoj fazi i fazi previranja. Oni smatraju dokazom da se međupovezanost između evropskih tržišta značajno povećala tokom perioda krize, ukazujući na pojačana prelivanja. Antonakakis i Vergos (Antonakakis, Vergos, 2013) ispituju suverenitet opsega prinosa od obveznica (BYS) tokom prelivanja između zemalja evrozone za vrijeme turbulentnog perioda koji obuhvata kako globalnu finansijsku krizu tako i dužničku krizu u evrozoni. Oni smatraju da su BYS prelivanja između zemalja evrozone veoma isprepletena i uglavnom potiču sa periferije i u manjoj mjeri iz samog jezgra.

Demiralay i Ulusoy (Demiralay, Ulusoy, 2016) pružaju dodatne empirijske dokaze da su se nivoi korelacije povećali tokom finansijske krize. Oni analiziraju vremenski promjenljiva ponašanja u međutržišnim korelacijama između tržišta u razvoju i razvijenih tržišta vođenih EGARCH modelom. Njihovi glavni rezultati pokazuju uzlazne modele korelacije, koji se odražavaju na povećanu integraciju tržišta kapitala tokom vremena. Dedi i Yavas (Dedi, Yavas, 2016) istražuju veze između učešća dohotka na tržištu i prenosa volatilnosti prije, za vrijeme i poslije finansijske krize 2007–2008, koristeći sredstva ETF-a u vodećim evropskim zemljama (Njemačka, Francuska, Italija, Velika Britanija) i SAD sprovodi GARCH model. Njihovi rezultati pokazuju značajnu povezanost kretanja dohotka u sva tri odabrana perioda. Oni su također pronašli dokaze o volatilnosti prelijevanja.

2. PODACI I METODOLOGIJA

U ovom istraživanju korišten je kapital ETF-a zasnovan na MSCI indeksima. MSCI indeksi za kapital globalno su usvojeni da budu "izbor za sredstvo poređenja" za međunarodne davaoce ETF kapitala (http://msci.com). Svi ETF subjekti koji su predmet ovog istraživanja izdati su od strane iShares i njima se trguje na NYSE Arca, prvoj elektronskoj berzi u Sjedinjenim Američkim Državama (BlackRock, 2017).

Berzanski ETF fondovi kombinuju osobine zajedničkih fondova i akcija. Sa ukupnim niskim troškovima, pristupom stotinama kompanija i fleksibilnošću trgovanja, ETF mogu da budu moćan dodatak u portfoliju investitora. Slično kao i uzajamnim fondovima, ETF su raznovrsne mješavine akcija ili obveznica kojima upravljaju iskusni profesionalci. Razlika je u tome što ETF obično ponudi nekoliko dodatnih bonusa, uključujući i niže troškove, poreske olakšice i mogućnost kupovine i prodaje tokom cijelog dana dok god je tržište otvoreno. Sa preko 1000 fondova na kojima se trguje valutama (ETF) širom svijeta i preko 1 triliona dolara u aktivi pod upravom menadžmenta (od 31. decembra 2014), iShares pomažu klijentima širom svijeta da sačine jezgro svojih portofolija, dostignu specifične investicione ciljeve i bolje sagledaju tržište. (Yavas, Dedi, 2016, str. 587).

Period za podatke je između 30. avgusta 2002. i 31. avgusta 2007, kao i 31. decembra 2009. i 31. decembra 2015, sve ukupno uzorak od 2769 dnevnih povrata (1259 u periodu pred krizu i 1510 u periodu nakon krize) na sljedećim ETF: 1. iShares MSCI France Capped ETF (EWQ) nastoji da prati rezultate investiranja indeksa MSCI France ("osnovni indeks"), koji se sastoji od akcija kojima se trguje primarno na pariškoj berzi; 2. iShares MSCI Germany ETF (EWG) nastoji da prati rezultate investiranja indeksa za MSCI njemački indeks, koji se sastoji od akcija kojima se trguje primarno

INTRODUCTION

This paper investigates volatility persistence and transmission of volatilities in the major European equity markets: France, Germany, Italy, Spain and UK. The selection was made on the basis of close economic relationships (trade and finance) among the sample countries with the objective of investigating market volatilities during a 5 year period before the 2008-2009 financial crisis and 6 year period after the crisis. One of the reasons for the selection was to study market co-movements between and among stronger countries of the EU (France, Germany and UK), and weaker countries (Italy and Spain) pre and post financial crisis. The research continues previous co-authored work on the same topic but with different markets and extended methodology.

The financial crisis of 2007 to 2009 has arguably been the first truly major global crisis since the Great Depression of 1929 to 1932. While the crisis initially had its origin in the United States in a relatively small segment of the lending market, the sub-prime mortgage market, it rapidly spread across virtually all economies, both advanced and emerging, as well as across economic sectors. It also affected equity markets worldwide, with many countries experiencing even sharper equity market crashes than the United States (Bekaert et al. 2014 p1).

The data period is divided into two separate periods: a five-year period before the 2008 financial crisis (from August 30, 2002 to August 31, 2007) and six years after the crisis (December 31, 2009 to December 31, 2015). The post-crisis period is until December 31, 2015 mainly to avoid the speculations about Brexit and from December 31, 2009 it covers a turbulent period in Europe.

The main motivation in this paper is to examine volatility linkages between major European equity markets by using country exchange traded funds (ETFs) based on MSCI indices with the main objective of contributing to the literature on different periods of volatility as manifested by the 2007-09 financial crisis and different equity markets.

1. LITERATURE REVIEW

Academic research in volatilities and volatility spillover has increased since 2007-09 financial crisis. Xiao and Dhesi (Xiao, Dhesi, 2010) examine volatility spillover effects and test time-varying correlations across four stock indices namely, CAC, DAX, FTSE100 and S&P500 spanning the period Jan 5, 2004 to Oct 1, 2009. They find that volatility spillover effects widely exist between the European and US stock markets. Interestingly, they find that the UK stock market is the main volatility transmitter within the European stock market while the US one is the main exporter worldwide. Samarakoon (Samarakoon, 2011) examines transmission of shocks between the U.S. and foreign markets. He found important bi-directional, yet asymmetric, interdependence and contagion in emerging markets, with important regional variations.

Jiang at al. (2012) examine the effect of US and European news announcements on the spillover of volatility across US and European stock markets. They provide evidence of significant implied volatility spillovers between US and European markets and across European markets. Their results are robust to extreme market events such as the recent financial crisis and provide evidence of volatility contagion across markets. Kenourgios D. and Padhi (Kenourgios, Padhi, 2012) investigates financial contagion of three emerging market crises of the late 1990s, as well as the subprime crisis of 2007, focusing on financial markets of emerging economies, USA and 2 global indices. They find that stock markets seem to constitute a stronger transmission mechanism during the three contagious crises.

Slimane at al. (Slimane at al., 2013) investigates the patterns of linkage dynamics among French, German and the UK stock markets during the global financial crisis, by analyzing the intraday dynamics of linkages among these markets during both calm and turmoil phases. They find evidence that interrelationship among European markets increased substantially during the period of crisis, pointing to an amplification of spillovers. Antonakakis and Vergos (Antonakakis, Vergos, 2013examine sovereign bond yield spread (BYS) spillovers between Euro zone countries during a turbulent period encompassing both the global financial crisis and the Euro zone debt crisis. They find that BYS spillovers between Euro zone countries are highly intertwined and originate mostly from periphery and to a lesser extent from core.

Demiralay and Ulusoy (Demiralay, Ulusoy, 2016) provide additional empirical evidence that the correlation levels increase during financial crises. They analyze the time-varying behavior of cross-market correlations between emerging and developed markets conducting EGARCH model. Their main results suggest the upward patterns of correlations, reflecting the increased equity market integration over time. Dedi and Yavas (Dedi, Yavas, 2016) investigates the linkages among equity market returns and transmission of volatilities before, during and after the 2007-08 crisis using exchange traded funds (ETFs) in the major European countries (Germany, France, Italy, UK) and the USA conducting GARCH model. Their results show significant co-movement of returns in all three selected periods. They also find evidence of volatility spillovers.

2. DATA AND METHODOLOGY

In this research Equity ETFs based on MSCI indexes are used. MSCI's equity indexes are globally adopted and continue to be the "benchmark of choice" for international equity ETF providers (http://msci.com). All ETFs subject to this study are issued by iShares and traded on the NYSE Arca, the first all-electronic exchange in the United States (BlackRock, 2017).

Exchange Traded Funds (ETFs) combine features of mutual funds and stocks. With low overall costs, access to hundreds of companies and trading flexibility, ETFs can be a powerful addition to investors' portfolio. Similar to mutual funds, ETFs are diversified mixes of stocks or bonds that are managed by experienced professionals. The difference is that ETFs typically offer a few extra perks, including lower fees, tax benefits and the ability to buy and sell throughout the day as long as the market is open. With over 1000 exchange-traded funds (ETFs) globally and more than $1 trillion in assets under management (as of December 31, 2014), iShares helps clients around the world build the core of their portfolios, meet specific investment goals and implement market views (Yavas, Dedi, 2016., p587).

The data period is from August 30, 2002 to August 31, 2007 and December 31, 2009 to December 31, 2015, all together a sample of 2769 daily returns (1259 in the pre-crisis period, and 1510 in the post-crisis period) on the following ETFs: 1. The iShares MSCI France Capped ETF (EWQ) seeks to track the investment results of the MSCI France Index (the "Underlying Index"), which consists of stocks traded primarily on the Paris Stock Exchange. 2. The iShares MSCI Germany ETF (EWG) seeks to track the investment results of the MSCI Germany Index, which consists of stocks traded primarily on the Frankfurt Stock Exchange. The MSCI Germany Index may

na berzi u Frankfurtu; MSCI njemački indeks može da uključuje velike, srednje ili male kapitalizacije kompanija (na primjer BASF, Allianz, Daimler AG, Adidas AG); 3. iShares MSCI Italy Capped ETF (EWI) nastoji da prati rezultate investiranja indeksa Italy 25/50, koji se sastoji od akcija kojima se trguje primarno na milanskoj berzi; 4. iShares MSCI Spain Capped ETF (EWU) nastoji da prati rezultate investiranja indeksa koji se sastoji od španskog kapitala; od 19. aprila 2017. godine neke od kompanija uključuju Banco Santander SA (18,32%), Telefonica SA (9,81%), Banco Bilbao Vizcaya Argentaria OR (4,43%); 5. iShares MSCI United Kingdom ETF (EWU) nastoji da prati rezultate investiranja indeksa MSCI Velika Britanija, koji primarno sadrži akcije kojima se trguje na londonskoj berzi, a od 19. aprila 2017. godine neke kompanije uključuju HSBC Holdings PLC (6,75%), British American Tobacco (5,31%), Royal Dutch Shell Plc Class A (4,81%) (BlackRock, 2017).

U periodu prije krize, kao što je prikazano u tabeli 1, glavni ETF povrati sa svih tržišta su pozitivni. U periodu nakon krize (tabela 2), svi glavni ETF povrati su negativni, osim na njemačkom tržištu.

Tabela 1. *Deskriptivna statistika (prije krize)*

	Francuska	Njemačka	Italija	Španija	V. Britanija
Mean	0.067991	0.077877	0.063797	0.093216	0.052475
Std. Dev.	1.204271	1.375522	1.010649	1.059943	1.024880
Skewness	-0.109964	-0.188272	-0.315409	-0.151691	-0.184365
Kurtosis	5.771692	5.474664	4.901342	4.420148	5.362498
Jarque-Bera	405.5367	328.6906	210.5170	110.6274	299.9232
Probability	0.000000	0.000000	0.000000	0.000000	0.000000
Observations	1259	1259	1259	1259	1259

**Svi rezultati su dobijeni u EViewsu*

Tabela 2. *Deskriptivna statistika (nakon krize)*

	Francuska	Njemačka	Italija	Španija	V. Britanija
Mean	-0.004909	0.010972	-0.022721	-0.035330	-0.000517
Std. Dev.	1.591166	1.547975	1.878270	1.850851	1.216537
Skewness	-0.075757	-0.187805	-0.147163	0.105310	-0.276458
Kurtosis	6.370189	5.653754	5.670016	7.139043	5.596331
Jarque-Bera	716.0627	451.9613	453.9824	1080.659	443.3517
Probability	0.000000	0.000000	0.000000	0.000000	0.000000
Observations	1510	1510	1510	1510	1510

**Svi rezultati su dobijeni u EViewsu*

Finansijska tržišta mogu lako da budu predmet ponovljenih mjehurića i padova (Claessens i Kose, 2013). Na primjer, najgore godine za njemačku berzu (indeks DAX) bile su 2002. sa -43,94% i 2008. sa -40,37% (vrijednost i prilika 2014). Još jedan primjer je londonska berza (indeks FTSE) – u 12 mjeseci nestabilnog trgovanja u 2008, FTS je pao 31% – najoštriji pad od kreiranja tog indeksa 1984. godine. Na početku godine, FTSE iznosio je 6456,9, a u 12.30 h poslije podne prvog dana nove godine (2008) bio je 4435,17 (Ruddick, 2008). Ovo je poznato kao „negativan stepen distribucije". Negativan stepen distribucije je negativan za sve zemlje osim za Španiju (u periodu nakon krize). Kutrozne mjere određuju učestalost i ravnomjernost distribucije. Na svim tržištima distribucija je na vrhuncu u oba perioda (> 3). Također, nulta hipoteza o normalnoj raspodjeli – distribuciji za sve povrate u uzorku α=0.05 odbijena je prema testu Jarque Bera (tabela 1. i tabela 2).

Najvišu volatilnost, mjerenu standardnom devijacijom, u periodu prije krize, pokazuju Njemačka (1,38) i Francuska (1,20). U periodu prije krize, italijansko tržište je imalo najnižu volatilnost (1,01). Situacija se kompletno promijenila u peridu nakon krize na italijanskom i španskom tržištu, koje je imalo najvišu volatilnost (1,88; 1,85). Tržište Velike Britanije imalo je najnižu volatilnost (1,22). Standardni izmijenjeni Dickley–Fullerov (ADF) test izveden je za nestacionirani povrat serije (vidjeti detaljnije u Brooks, 2014). Rezultati su potvrdili stacioniranost podataka.

Finansijski analitičari koji su posmatrali dnevne povrate primijetili su da amplituda povrata varira tokom vremena i ovo su opisali kao "grupisanje volatilnosti". ARCH i GARCH modeli, koji važe za autoregresivne, uslovne i heteroskedastične i generalizovano autoregresivno uslovno heteroskedastične, dizajnirani su da se bave ovakvim skupom problema. Postali su široko rasprostranjeni alati za bavljenje heteroskedastičkim modelima vremenskih serija. Cilj ovih modela je da obezbijedi mjeru volatilnosti (kao standardnu devijaciju) koja se može koristiti u donošenju finansijskih odluka u vezi sa analizom rizika, izborom portofolija i određivanjem cijena finansijskih derivata (Engle, 2001, str. 58).

U ovom radu, GARCH (1, 1) i EGARCH (1, 1) korišteni su za ispitivanje volatilnosti i GARCH prenos volatilnosti. Čitalac se upućuje na Engle (Engle, 1982), Bollerslev (Bollerslev, 1986), Nelson (Nelson, 1991), Duan (Duan, 1997), Brooks (Brooks, 2014) i Alexander (Alexander, 2008) za dodatne informacije za GARCH model.

Jedno od primarnih ograničenja GARCH modela jeste to što primjenjuje simetrični odgovor volatilnosti za pozitivne i negativne šokove. Međutim, kako bi se prevazišao ovaj problem, predloženi

include large-, mid- or small capitalization companies (for example BASF, Allianz, Daimler AG, Adidas AG). 3. The iShares MSCI Italy Capped ETF (EWI) seeks to track the investment results of the MSCI Italy 25/50 Index, which consists of stocks traded primarily on the Milan Stock Exchange. 4. The iShares MSCI Spain Capped ETF (EWU) seeks to track the investment results of an index composed of Spanish equities. As of April 19, 2017 some of the holdings include Banco Santander SA (18.32%), Telefonica SA (9.81%), Banco Bilbao Vizcaya Argentaria OR (4.43%). 5. The iShares MSCI United Kingdom ETF (EWU) seeks to track the investment results of the MSCI United Kingdom Index, which consists of stocks traded primarily on the London Stock Exchange. As of April 19, 2017 some of the holdings include HSBC Holdings PLC (6.75%), British American Tobacco (5.31%), Royal Dutch Shell Plc Class A (4.81%) (BlackRock, 2017).

In the pre-crisis period, as presented in Table 1, mean ETF returns from all of the markets are positive. In the post-crisis period (Table 2) all mean ETF returns are negative, except for German market.

Table 1. *Descriptive statistics* (pre-crisis)*

	FRANCE	GERMANY	ITALY	SPAIN	UK
Mean	0.067991	0.077877	0.063797	0.093216	0.052475
Std. Dev.	1.204271	1.375522	1.010649	1.059943	1.024880
Skewness	-0.109964	-0.188272	-0.315409	-0.151691	-0.184365
Kurtosis	5.771692	5.474664	4.901342	4.420148	5.362498
Jarque-Bera	405.5367	328.6906	210.5170	110.6274	299.9232
Probability	0.000000	0.000000	0.000000	0.000000	0.000000
Observations	1259	1259	1259	1259	1259

**All results are obtained in EViews*

Table 2. *Descriptive statistics* (post-crisis)*

	FRANCE	GERMANY	ITALY	SPAIN	UK
Mean	-0.004909	0.010972	-0.022721	-0.035330	-0.000517
Std. Dev.	1.591166	1.547975	1.878270	1.850851	1.216537
Skewness	-0.075757	-0.187805	-0.147163	0.105310	-0.276458
Kurtosis	6.370189	5.653754	5.670016	7.139043	5.596331
Jarque-Bera	716.0627	451.9613	453.9824	1080.659	443.3517
Probability	0.000000	0.000000	0.000000	0.000000	0.000000
Observations	1510	1510	1510	1510	1510

**All results are obtained in EViews*

Financial markets can easily be subject to repeated bubbles and crashes (Claessens and Kose, 2013). For example, the worst years for German Stock Index DAX were 2002 with -43.94% and 2008 with -40.37% (Value and opportunity, 2014). Another example is London Stock Exchange Index FTSE, in 12 months of volatile trading in 2008, the FTSE fell 31% – the sharpest drop since the current index was created in 1984. Opening the year on 6456.90, the FTSE closed at 12.30pm on New Year's Eve (2008) at 4434.17 (Ruddick, 2008). This is known as „negative skewness". Skewness is negative for all countries except for Spain (in post-crisis period). Kurtosis measures the peakedness or flatness of the distribution. In all markets the distribution is peaked in both periods (kurtosis > 3). Also, the null hypothesis of normal distribution for all returns in the sample at α=0.05 is rejected according to the Jarque Bera test (Table 1 and Table 2).

The highest volatility, measured by standard deviation, in the pre-crisis period is exhibited by Germany (1.38) and France (1.20). In the pre-crisis period Italian market had the lowest volatility (1.01). The situation completely changed in the post-crisis period for Italian and Spanish markets which exhibited the highest volatility (1.88), (1.85). The UK market has the lowest volatility (1.22). The standard Augmented Dickley-Fuller (ADF) test has been performed for nonstationarity of return series (see for details in Brooks, 2014). The results confirmed the stationarity of the data.

Financial analysts, looking at plots of daily returns, notice that the amplitude of the returns varies over time and describe this as "volatility clustering". The ARCH and GARCH models, which stand for autoregressive conditional heteroskedasticity and generalized autoregressive conditional heteroskedasticity, are designed to deal with just this set of issues. They have become widespread tools for dealing with time series heteroskedastic models. The goal of such models is to provide a volatility measure (like a standard deviation) that can be used in financial decisions concerning risk analysis, portfolio selection and derivative pricing (Engle, 2001, p158).

In this paper GARCH (1, 1) and EGARCH (1, 1) are used to study volatility persistence and Augmented GARCH for volatility transmission. The reader is referred to Engle (Engle, 1982), Bollerslev (Bollerslev, 1986), Nelson (Nelson, 1991), Duan (Duan, 1997), Brooks (Brooks, 2014) i Alexander (Alexander, 2008)for additional information on GARCH models.

One of the primary restrictions of GARCH models is that they enforce a symmetric response of volatility to positive and negative shocks. However, to overcome that problem, asymmetric GARCH models have been proposed. One of them is the EGARCH proposed

su asimetrični modeli GARCH. Jedan od njih je EGARCH, predložen od strane Nelsona (Nelson, 1991), asimetrični model koji određuje algoritam uslovne volatilnosti i izbjegava potrebu za bilo kojim ograničenjima parametara (Brooks, 2014).

3. REZULTATI ISTRAŽIVANJA

Da bi se analizirala postojanost volatilnosti i sama volatilnost, Engleov (Engle, 1982) test je izračunao kako bi se provjerila primjerenost modela. Engleov test je za zemlje koje su uzete kao uzorak rezultirao prisustvo ARCH efekata u EFT povratima i ukazao na to da su modeli tipa GARCH prikladniji za podatke. Dnevni ETF povrati su izračunati pomoću logaritma 100* razlike u dnevnoj krajnjoj vrijednosti ETF $r_t = 100 * d\log(p_t)$.

3.1. Postojanost volatilnosti

Da bi se analizirala kratkoročna i dugoročna istrajnost volatilnosti, obično se koristi specifikacija GARCH (1,1). Postojanost volatilnosti jedna je od statističkih mogućnosti povrata i deviznih kurseva. Volatilnost se pojavljuje u klasterima, drugim riječima, velike promjene u cijenama aktive se ne zaustavljaju iznenada nakon velikih slomova, već umjesto toga imaju tendenciju da nastave u tom smjeru. Ova postojanost volatilnosti znači da su očekivanja volatilnosti učesnika na tržištu pod uticajem njihovih saznanja o visokoj volatilnosti (Poterba & Summers, 1986).

Rezultati GARACH (1,1) predstavljeni su u tabelama 3. i 4. Kako je pokazano u tabeli 3, u periodu prije krize, najviši Arch koeficijent pokazuje se u Velikoj Britaniji (0,07), što znači da je volatilnost veoma osjetljiva na događaje na tržištu i berzi. Italija i Španija imaju najniže Arch koeficijente (0.0488 i 0.0489), što ukazuje na stabilnu kratkoročnu volatilnost.

Tabela 3. *Rezultati procjene GARCH (1, 1)* – prije krize*

	Francuska	Njemačka	Italija	Španija	V. Britanija
Constant (ω)	0.0226 (0.008)	0.0187 (0.016)	0.0150 (0.028)	0.0168 (0.022)	0.0205 (0.007)
ARCH(-1) (α)	0.0667 (0.000)	0.0609 (0.000)	0.0488 (0.000)	0.0489 (0.000)	0.0712 (0.000)
GARCH(-1) (β)	0.9119 (0.000)	0.9237 (0.000)	0.9335 (0.000)	0.9333 (0.000)	0.9062 (0.000)
α +β<1	0.9786	0.9846	0.9824	0.9822	0.9774
AIC	2.9237	3.1367	2.6894	2.8013	2.6669
SIC	2.9440	3.1571	2.7098	2.8217	2.6873
ARCH-LM test statistic (Obs*R-squared)	0.4490	0.0064	0.0468	0.1218	0.0003
Prob. Chi-Square(1)	0.5028	0.9365	0.8287	0.7271	0.9846

**Svi rezultati su dobijeni u EViewsu*

GARCH parametar ß mjeri dugoročne efekte na prinose od prošlih šokova. Kreće se u rasponu od 0,85 do 0,99. Kako je pokazano u tabeli 3, ß je u rasponu od 0,9062 u Velikoj Britaniji do 0,9335 u Italiji. Konačno, postojanost volatilnosti mjerena sumom α i ß (Arch i Garch efekta) najviša je u Njemačkoj (0,9846), Italiji (0,9834) i Španiji (0,9822), što znači da je volatilnosti potrebno mnogo više vremena da nestane nego u Velikoj Britaniji i Francuskoj. Velika Britanija se ističe u ovom uzorku jer ima relativno visok ARCH koeficijent koji pokazuje da je volatilnost mnogo osjetljivija na događaje na tržištu. S druge strane, ima relativno nizak GARCH koeficijent, koji pokazuje da je šokovima u uslovnim varijansama potrebno manje vremena da nestanu.

U periodu nakon krize, kako je prikazano u tabeli 4, najnižu α vrijednost imala je Njemačka (0,0571), što znači da volatilnost nije veoma osjetljiva na tržišne događaje, dok je u Velikoj Britaniji ta vrijednost najviša. U ovoj analizi, tržište Velike Britanije ima najnižu vrijednost ß (0,8862), dok tržište u Njemačkoj ima najvišu ß (0,9912). Na kraju, istrajnost u volatilnosti, mjerena zbirom α i je ß, najviša je u Francuskoj (0,9912) i Njemačkoj (0,9903). Na oba tržišta, kad je α + ß vrijednost blizu 1,0, to znači da volatilnosti treba duže vrijeme da nestane. Velika Britanija se ističe u ovom uzorku jer ima relativno visoku vrijednost α (višu nego u periodu prije krize), što pokazuje da volatilnost reaguje intenzivnije na tržišna kretanja nego u periodu prije krize. S druge strane, ima relativno nisku vrijednost ß (nižu nego u periodu prije krize), što ukazuje na to da šokovi u uslovnim varijantama brzo nestaju. U ovakvim slučajevima, volatilnost ima tendenciju da bude "oštrija". ARCH LM test (tabela 3. i tabela 4) potvrđuje da nema ARCH efekata u standardnim rezidualima.

Tabela 4. *Procjene rezultata po GARCH (1, 1)* – nakon krize*

	France	Germany	Italy	Spain	UK
Constant (ω)	0.0225 (0.025)	0.0224 (0.042)	0.0547 (0.021)	0.0442 (0.021)	0.0376 (0.001)
ARCH(-1) (α)	0.0647 (0.000)	0.0571 (0.000)	0.0636 (0.000)	0.0663 (0.000)	0.0903 (0.000)
GARCH(-1) (β)	0.9265 (0.000)	0.9332 (0.000)	0.9203 (0.000)	0.9211 (0.000)	0.8862 (0.000)
α +β<1	0.9912	0.9903	0.9839	0.9873	0.9765

by Nelson (Nelson, 1991), an asymmetric model that specifies the logarithm of the conditional volatility and avoids the need for any parameters constraints (Brooks, 2014).

3. FINDINGS

In order to analyze the volatility persistence and or volatility spillover Engle (Engle, 1982) test was computed to check the appropriateness of the model. The Engle test results for sample countries confirmed the presence of ARCH effects in the ETFs returns indicating that the GARCH type models are appropriate for the data. Daily ETF returns are calculated by 100* logarithmic difference of daily closing ETF values: $r_t = 100 * d\log(p_t)$.

3.1. Volatility persistence

To analyze short term and long-term persistence in volatility, GARCH (1, 1) specification is commonly used. Volatility persistence is one of the statistical properties of time stock returns and exchange rates. Volatility occurs in clusters, in other word, major swings in asset prices do not suddenly stop after major news breaks, and instead they tend to persist. This volatility persistence means that the market participants' volatility expectations are influenced by their perception of high volatility (Poterba & Summers, 1986).

Results of GARCH (1, 1) are presented in tables 3 and 4. As shown in the table 3, in the pre-crisis period the highest Arch coefficient is exhibited by the UK (0.07) meaning that volatility is very sensitive to market events or shocks. Italy and Spain have the lowest Arch coefficient (0.0488 and 0.0489) indicating stable short term volatility.

Table 3. *Estimation results of GARCH (1, 1)* – pre-crisis*

	France	Germany	Italy	Spain	UK
Constant (ω)	0.0226 (0.008)	0.0187 (0.016)	0.0150 (0.028)	0.0168 (0.022)	0.0205 (0.007)
ARCH(-1) (α)	0.0667 (0.000)	0.0609 (0.000)	0.0488 (0.000)	0.0489 (0.000)	0.0712 (0.000)
GARCH(-1) (β)	0.9119 (0.000)	0.9237 (0.000)	0.9335 (0.000)	0.9333 (0.000)	0.9062 (0.000)
α +β<1	0.9786	0.9846	0.9824	0.9822	0.9774
AIC	2.9237	3.1367	2.6894	2.8013	2.6669
SIC	2.9440	3.1571	2.7098	2.8217	2.6873
ARCH-LM test statistic (Obs*R-squared)	0.4490	0.0064	0.0468	0.1218	0.0003
Prob. Chi-Square(1)	0.5028	0.9365	0.8287	0.7271	0.9846

**All results are obtained in EViews*

GARCH parameter ß measures a long term effect of past shocks on returns. It ranges between 0.85 and 0.99. As shown in table 3, ß ranges from 0.9062 in UK to 0.9335 in Italy. Finally persistence in volatility, as measured by the sum of α and ß (Arch and Garch effects) is the highest for Germany (0.9846), Italy (0.9824) and Spain (0.9822) meaning that the volatility takes a longer time to die out than in UK and France. UK stands out in the sample because it has a relatively high ARCH coefficient indicating that the volatility is much more sensitive to market events. On the other hand it has a relatively low GARCH coefficient which indicates that shocks to conditional variance take a short time die out.

In the post-crisis period, as shown in the table 4, the lowest α value is exhibited by Germany (0.0571) meaning that volatility is not very sensitive to market events, while UK has the highest α value. In this analysis UK market has the lowest value of ß (0.8862) while German market has the highest ß value (0.9332). Finally persistence in volatility, as measured by the sum of α and ß, is the highest in France (0.9912) and Germany (0.9903). Both markets have α + ß value close to 1.0 meaning that the volatility takes a longer time to die out. UK stands out in the sample, because it has a relatively high α value (higher than in the pre-crisis period) indicating that the volatility reacts more intensely to market movements than in the pre-crisis period. On the other hand it has a relatively low ß value (lower than in the pre-crisis) which indicates that shocks to conditional variance fade away very shortly. In such cases, volatility tends to be more 'spiky'. ARCH LM test (table 3 and table 4) confirms that there are no ARCH effects left in the standardized residuals.

Table 4. *Estimation results of GARCH (1, 1)* – post-crisis*

	France	Germany	Italy	Spain	UK
Constant (ω)	0.0225 (0.025)	0.0224 (0.042)	0.0547 (0.021)	0.0442 (0.021)	0.0376 (0.001)
ARCH(-1) (α)	0.0647 (0.000)	0.0571 (0.000)	0.0636 (0.000)	0.0663 (0.000)	0.0903 (0.000)
GARCH(-1) (β)	0.9265 (0.000)	0.9332 (0.000)	0.9203 (0.000)	0.9211 (0.000)	0.8862 (0.000)
α +β<1	0.9912	0.9903	0.9839	0.9873	0.9765
AIC	3.5127	3.4778	3.8996	3.8463	3.0224
SIC	3.5303	3.4954	3.9172	3.8639	3.0399

AIC	3.5127	3.4778	3.8996	3.8463	3.0224
SIC	3.5303	3.4954	3.9172	3.8639	3.0399
ARCH-LM test statistic (Obs*R-squared)	0.1196	0.4439	0.2410	0.0119	0.1836
Prob. Chi-Square(1)	0.7295	0.5052	0.6235	0.9128	0.6683

**Svi rezultati su dobijeni u EViewsu*

Kako je ranije pokazano, čisti GARCH model sprovodi simetrični odgovor volatilnosti na pozitivne i negativne šokove. S druge strane, E-GARCH je asimetričan GARCH model koji ne određuje uslovnu varijansu već logaritam uslovne volatilnosti. Zbog toga se izbjegava potreba za ograničenjem bilo kojih parametara. Opštepoznato je da ovaj model odgovara bolje u odnosu na druge vrste procesa (detaljnije vidjeti Alexander, 2008, str. 133). EGARCH modelira varijansu kao funkciju varijanse zaostajućeg logaritma i zaostale apsolutne greške iz regresijskog modela. Rezultati EGARCH predstavljeni su u nastavku (tabele 5. i 6). Termin asimetrije EGARTH g je negativan i veoma značajan za sva tržišta u oba perioda, što ukazuje na to da se volatilnost više povećava kad je tržište u padu. To znači da su investitori više osjetljivi na negativne nego na pozitivne vijesti, pogotovo nakon krize gdje je asimetričnost mnogo viša za sve zemlje koje su uzete kao uzorci.

Tabela 5. *Rezultati procjene EGARCH (1,1)* – prije krize*

	France	Germany	Italy	Spain	UK
Constant (w)	-0.0891 (0.000)	-0.0933 (0.000)	-0.0815 (0.000)	-0.1025 (0.000)	-0.1076 (0.000)
÷(RES(-1)ç/@SQRT (GARCH(-1)) (a)	0.1129 (0.000)	0.1219 (0.000)	0.0995 (0.000)	0.1276 (0.000)	0.1307 (0.000)
RES(-1)/@SQRT (GARCH(-1)) (g)	-0.0636 (0.000)	-0.0443 (0.004)	-0.0317 (0.037)	-0.0482 (0.005)	-0.0618 (0.000)
LOG(GARCH(-1)) (b)	0.9822 (0.000)	0.9843 (0.000)	0.9812 (0.000)	0.9726 (0.000)	0.9765 (0.000)
AIC	2.9209	3.1375	2.6923	2.7979	2.6671
SIC	2.9455	3.1579	2.7168	2.8225	2.6915
ARCH-LM test statistic (Obs*R-squared)	0.2144	0.1081	0.0485	0.1971	0.1401
Prob. Chi-Square(1)	0.6433	0.7423	0.8257	0.6571	0.7082

**Svi rezultati su dobijeni u EViewsu*

Parametar istrajnosti b je viši i gotovo isti za francusko tržište (0,982), njemačko tržište (0,984) i italijansko tržište (0,981) u periodu prije krize i za španjsko tržište (0,985) i njemačko tržište (0,985) u periodu nakon krize, što ukazuje na to da volatilnost sporo nestaje. Parametar istrajnosti b je najmanji za tržište Španije i Velike Britanije (prije krize) i Velike Britanije (nakon krize). Robusnost modela potvrđena je rezultatima procjene testa (tabele 5. i 6).

Tabela 6. *Procjena rezultata EGARCH (1, 1)* – nakon krize*

	France	Germany	Italy	Spain	UK
Constant (w)	-0.0745 (0.000)	-0.0645 (0.000)	-0.0505 (0.003)	-0.0559 (0.000)	-0.0836 (0.000)
÷(RES(-1)ç/@SQRT (GARCH(-1)) (a)	0.1126 (0.000)	0.0963 (0.000)	0.0935 (0.000)	0.0914 (0.000)	0.1155 (0.000)
RES(-1)/@SQRT (GARCH(-1)) (g)	-0.1124 (0.000)	-0.0877 (0.000)	-0.0959 (0.000)	-0.0891 (0.000)	-0.1404 (0.000)
LOG(GARCH(-1)) (b)	0.9801 (0.000)	0.9843 (0.000)	0.9784 (0.000)	0.9849 (0.000)	0.9647 (0.000)
AIC	3.4868	3.4567	3.8816	3.8216	2.9922
SIC	3.5079	3.4779	3.9028	3.8428	3.0133
ARCH-LM test statistic (Obs*R-squared)	0.0131	0.5486	0.4491	0.2866	0.8199
Prob. Chi-Square(1)	0.9088	0.4589	0.5028	0.5924	0.3652

**Svi rezultati su dobijeni u EViewsu*

Konačno, kriterijumi AIC i SIC upoređeni su da provjere koji je model bolji, GARCH (1,1) ili EGARCH (1,1). U periodu prije krize EGARCH ne daje bolje rezultate ni na jednom odabranom tržištu. Ovo nije iznenađenje, a kao što je i ranije primijećeno, prema EGARCH, "loše"

ARCH-LM test statistic (Obs*R-squared)	0.1196	0.4439	0.2410	0.0119	0.1836
Prob. Chi-Square(1)	0.7295	0.5052	0.6235	0.9128	0.6683

**All results are obtained in EViews*

As noted earlier, pure GARCH model enforce a symmetric response of volatility to positive and negative shocks. On the other hand, the E-GARCH is an asymmetric GARCH model that specifies not the conditional variance but the logarithm of the conditional volatility. Thus the need for any parameters constraints is avoided. It is widely recognized that this model provides a better in-sample fit than other types of GARCH process (see for details in Alexander 2008, p133). EGARCH models the log of the variance as a function of the lagged log variance and the lagged absolute error from the regression model.

EGARCH results are presented below (tables 5 and 6). The EGARCH asymmetry term g is negative and highly significant for all markets in both periods indicating that volatility increases more when market is falling. It means that investors are more sensitive to the negative news than to positive, especially in after-crisis period where asymmetry term is much higher for all sample countries.

Table 5. *Estimation results of EGARCH (1,1)* – pre-crisis*

	France	Germany	Italy	Spain	UK
Constant (w)	-0.0891 (0.000)	-0.0933 (0.000)	-0.0815 (0.000)	-0.1025 (0.000)	-0.1076 (0.000)
÷(RES(-1)ç/@SQRT (GARCH(-1)) (a)	0.1129 (0.000)	0.1219 (0.000)	0.0995 (0.000)	0.1276 (0.000)	0.1307 (0.000)
RES(-1)/@SQRT (GARCH(-1)) (g)	-0.0636 (0.000)	-0.0443 (0.004)	-0.0317 (0.037)	-0.0482 (0.005)	-0.0618 (0.000)
LOG(GARCH(-1)) (b)	0.9822 (0.000)	0.9843 (0.000)	0.9812 (0.000)	0.9726 (0.000)	0.9765 (0.000)
AIC	2.9209	3.1375	2.6923	2.7979	2.6671
SIC	2.9455	3.1579	2.7168	2.8225	2.6915
ARCH-LM test statistic (Obs*R-squared)	0.2144	0.1081	0.0485	0.1971	0.1401
Prob. Chi-Square(1)	0.6433	0.7423	0.8257	0.6571	0.7082

**All results are obtained in EViews*

The persistence parameter b is higher and almost the same for French market (0.982), German (0.984) and Italian market (0.981) in the pre-crisis period and for Spanish market (0.985) and German market (0.985) in the post-crisis period, indicating that volatility fade away slowly. The persistence parameter b is smallest for the Spanish and UK market (per-crisis) and UK (post-crisis). The robustness of the model is confirmed with the post estimation tests (table 5 and 6).

Table 6. *Estimation results of EGARCH (1, 1)* – post - crisis*

	France	Germany	Italy	Spain	UK
Constant (w)	-0.0745 (0.000)	-0.0645 (0.000)	-0.0505 (0.003)	-0.0559 (0.000)	-0.0836 (0.000)
÷(RES(-1)ç/@SQRT (GARCH(-1)) (a)	0.1126 (0.000)	0.0963 (0.000)	0.0935 (0.000)	0.0914 (0.000)	0.1155 (0.000)
RES(-1)/@SQRT (GARCH(-1)) (g)	-0.1124 (0.000)	-0.0877 (0.000)	-0.0959 (0.000)	-0.0891 (0.000)	-0.1404 (0.000)
LOG(GARCH(-1)) (b)	0.9801 (0.000)	0.9843 (0.000)	0.9784 (0.000)	0.9849 (0.000)	0.9647 (0.000)
AIC	3.4868	3.4567	3.8816	3.8216	2.9922
SIC	3.5079	3.4779	3.9028	3.8428	3.0133
ARCH-LM test statistic (Obs*R-squared)	0.0131	0.5486	0.4491	0.2866	0.8199
Prob. Chi-Square(1)	0.9088	0.4589	0.5028	0.5924	0.3652

**All results are obtained in EViews*

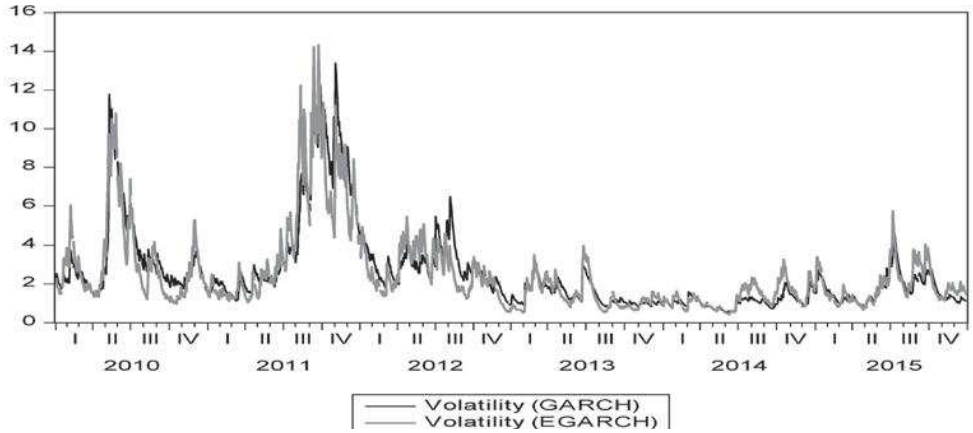
Finally, AIC and SIC criterion are compared to check which model is better, GARCH (1, 1) or EGARCH (1, 1). In the pre-crisis period EGARCH does not give better results for any of the selected markets. This is not a surprise because, as noted earlier, according to EGARCH

vijesti ili događaji imaju jači uticaj na volatilnost i u odabranim tržištima u periodu nakon krize i nisu pretrpjeli tako negativne šokove koji bi bolje odgovarali prema EGARCH.

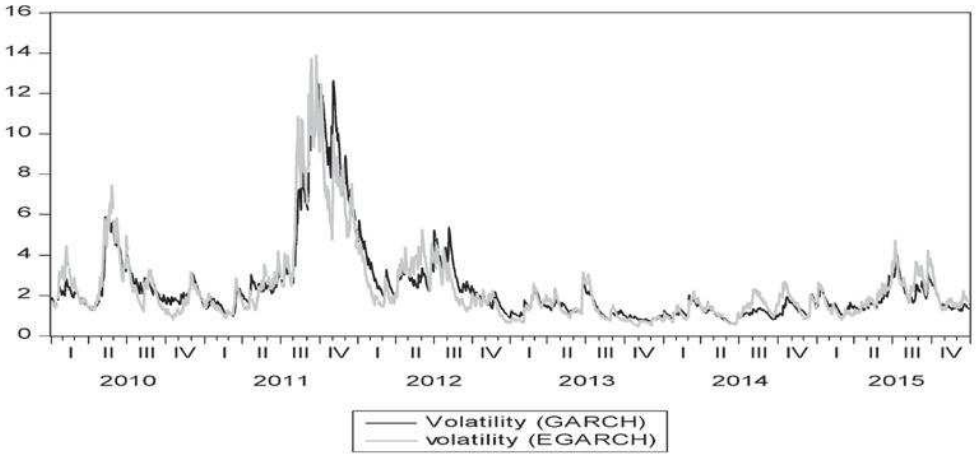
Međutim, suprotno je tačno u periodu nakon krize. AIC i SIC kriterijumi za EGARCH (1,1) malo su manji u periodu nakon krize za Francusku, Njemačku, Italiju, Španiju i Veliku Britaniju nego za čisti GARCH (1,1). Može se zaključiti da je EGARCH (1,1) bolji model.

Pokazatelji 1–3. pokazuju varijacije na ETF povrat (GARCH protiv EGARCH) za period nakon krize za tržište Francuske, Njemačke i Velike Britanije.

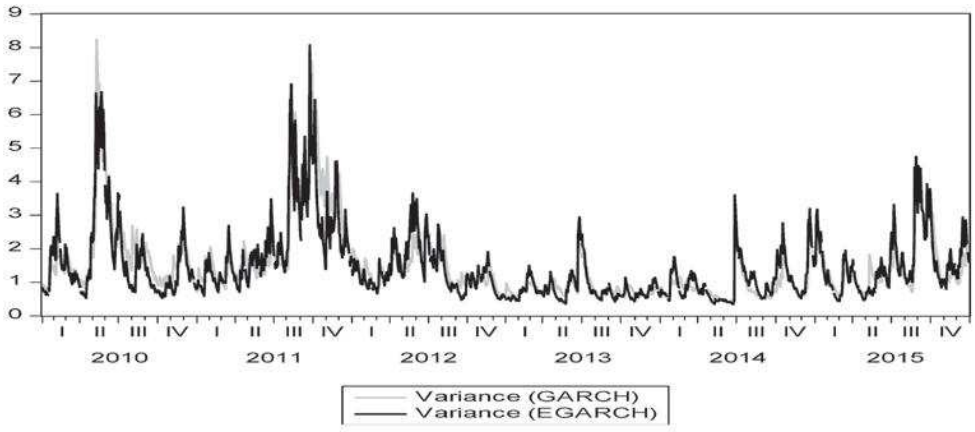
Pokazatelj 1: *Varijacije povrata ETF GARCH /EGARCH za Francusku (nakon krize)*



Pokazatelj 2: *Varijacije povrata GARCH /EGARCH za Njemačku (nakon krize)*



Pokazatelj 3: *Varijacije povrata GARCH /EGARCH za Veliku Britaniju (nakon krize)*



3.2. Prenos volatilnosti

Kao što je primijećeno ranije, model povećanog GARCH-a (Duan, 1997) korišćen je da analizira prenos volatilnosti. U analizi se koriste kvadratići prenosa za zaostali period jer AR ili ARMA ne mogu da odgovaraju bilo kojim povratima.

Saznanja su naznačena u tabeli 7. (prije krize) i tabeli 8. (nakon krize). U periodu prije krize, volatilnost sa drugih tržišta nije se prenijela na tržište Velike Britanije. Međutim, volatilnost sa tržišta Velike Britanije prenosi se na sva ostala tržišta koja smo analizirali.

"bad" news or events have a greater impact on volatility and in the selected pre-crisis period markets did not experience such a negative shocks that could be better fitted by EGARCH. However, the opposite is true in the post-crisis period. AIC and SIC criterion for EGARCH (1, 1) are a little bit smaller in the post-crisis period for France, Germany, Italy, Spain and UK than for pure GARCH (1, 1). It can be concluded that EGARCH (1, 1) is a better model.

Figures 1-3 below depict variances of ETF returns (GARCH vs EGARCH) in the post-crisis period for French, German and UK market.

Figure 1. *Variances of ETF returns GARCH /EGARCH for France (post-crisis)*

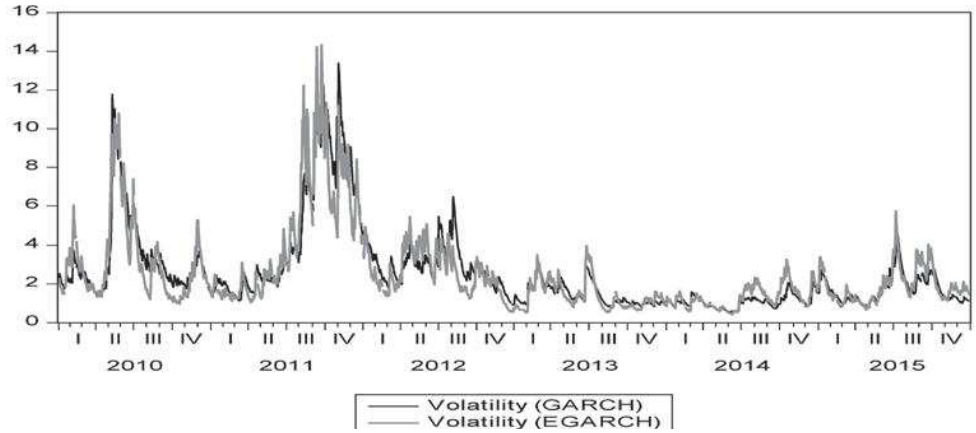


Figure 2. *Variances of ETF returns GARCH /EGARCH for Germany (post-crisis)*

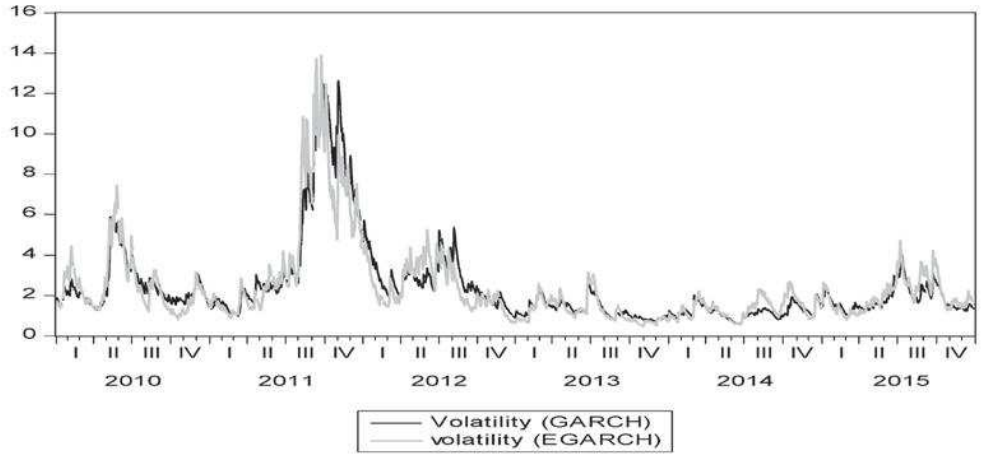
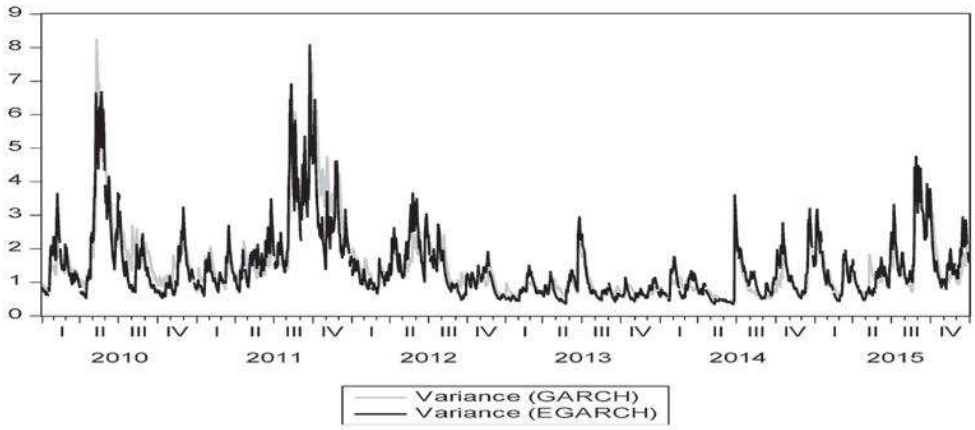


Figure 3. *Variances of ETF returns GARCH /EGARCH for UK (post-crisis)*



3.2. Volatility transmission

As noted earlier, the Augmented GARCH model (Duan, 1997) is used to analyze volatility transmission. One-period lagged squared returns are used in the analysis because AR or ARMA could not be fitted to any of the returns. Therefore, the paper reports volatility transmission of past period returns.

The findings are indicated in Table 7 (pre-crisis) and Table 8 (post-crisis). In the pre-crisis period, volatility from other markets is not transmitted to the UK market. However, volatility from the UK market transmits to all other analyzed markets.

Tabela 7. *Prenos volatilnosti* (prije krize)*

$s^2_{t(France)} = 0.011 + 0.929s^2_{t-1(France)} + 0.080r^2_{t-1(UK)}$
$s^2_{t(Germany)} = 0.010 + 0.048e^2_{t-1(Germany)} + 0.926s^2_{t-1(Germany)} + 0.031r^2_{t-1(UK)}$
$s^2_{t(Italy)} = 0.021 + 0.923s^2_{t-1(Italy)} + 0.053r^2_{t-1(UK)}$
$s^2_{t(Spain)} = 0.022 + 0.925s^2_{t-1(Spain)} + 0.059r^2_{t-1(UK)}$
$s^2_{t(UK)} = 0.020 + 0.071e^2_{t-1(UK)} + 0.906s^2_{t-1(UK)}$

**Svi rezultati su dobijeni u EViewsu*

Tabela 8. *Prenos volatilnosti * (nakon krize)*

$s^2_{t(France)} = 0.040 + 0.103e^2_{t-1(France)} + 0.912s^2_{t-1(France)} - 0.021r^2_{t-1(Italy)}$
$s^2_{t(Germany)} = 0.022 + 0.057e^2_{t-1(Germany)} + 0.933s^2_{t-1(Germany)}$
$s^2_{t(Italy)} = 0.058 + 0.037e^2_{t-1(Italy)} + 0.915s^2_{t-1(Italy)} + 0.046r^2_{t-1(Germany)}$
$s^2_{t(Spain)} = 0.053 + 0.037e^2_{t-1(Spain)} + 0.907s^2_{t-1(Spain)} + 0.057r^2_{t-1(France)}$
$s^2_{t(UK)} = 0.047 + 0.075e^2_{t-1(UK)} + 0.883s^2_{t-1(UK)} + 0.040r^2_{t-1(France)} - 0.023r^2_{t-1(Italy)}$

**Svi rezultati su dobijeni u EViewsu*

U periodu nakon krize, nestabilnost (volatilnost) tržišta Njemačke prelila se i na tržište Italije. Međutim, rezultati pokazuju da nema prenosa sa ostalih tržišta na tržište Njemačke. Nestabilnost sa tržišta Francuske prelila se na tržište Španije i Velike Britanije. Volatilnost sa tržišta Italije prelila se na tržište Francuske i Velike Britanije, ali uticaj je obrnut. Nestabilnost sa tržišta Francuske prenosi se na Španiju, ali se ne prenosi iz Španije u Francusku.

ZAKLJUČNE NAPOMENE

Ovaj rad istražuje postojanost volatilnosti (nestabilnosti) i prelivanje nestabilnosti između pet evropskih zemalja (Francuska, Njemačka, Italija, Španija i Velika Britanija) od 30. avgusta 2002. do 31. avgusta 2007. i od 31. decembra 2009. do 31. decembra 2015. godine. GARCH i EGARCH (1,1) korišteni su za dnevne povrate na zemlje ETF radi ispitivanja upadljivosti volatilnosti i povećanja GARCH-a za prenos volatilnosti.

Najviši nivo nestabilnosti u periodu prije krize pokazao se u Njemačkoj i Francuskoj, a najniži u Italiji. U periodu nakon krize, tržište Italije pokazalo je najvišu volatilnost, a u Velikoj Britaniji je ona bila najniža. Istraživanje volatilnosti u kratkom periodu pokazalo je da je nestabilnost tržišta u Velikoj Britaniji oštra, ali se ne zadržava dugo (prije i nakon krize). S druge strane, rezultati su pokazali da u Njemačkoj (prije i nakon krize) tržište nije nestabilno u kratkom roku, ali dugoročno, efekti prošlih šokova na zarade imaju najjači uticaj u odabranim zemljama i istovremeno te posljedice na nestabilnost traju veoma dugo.

Prezentovani EGARCH (1,1) rezultati pokazuju da su investitori više osjetljivi na negativne vijesti u periodu nakon krize. EGARCH (1,1) se pokazao kao bolji za sva tržišta u periodu nakon krize.

Saznanja o prenosu volatilnosti u periodu prije krize pokazuju da je tržište Velike Britanije jedino tržište koje nije iskusilo prelivanje nestabilnosti sa ostalih tržišta, ali s druge strane, nestabilnost na tržištu Velike Britanije prenosila se na sva tržišta koja smo analizirali. Ovi rezultati su u skladu sa saznanjima do kojih su došli Xiao i Dhesi (Xiao, Dhesi, 2010). Nakon krize, rezultati su pokazali da nema prenosa volatilnosti sa ostalih tržišta na njemačko tržište. Također, nestabilnost sa tržišta Španije i Velika Britanije ne preliva se na druga tržišta. Nestabilnost sa tržišta Francuske preliva se na tržište Španije i Velike Britanije. Konačno, u periodu nakon krize bio je obrnut uticaj volatilnosti tržišta Italije na volatilnost tržišta Francuske i Velike Britanije.

Države evrozone su u većoj korelaciji nakon krize. Također, države evrozone su više u korelaciji sa Velikom Britanijom nakon krize. Podaci za volatilnost i prenos volatilnosti mogu biti vrlo korisni za portfolio menadžerima i investitorima koji žele efikasno da diverzifikuju svoja ulaganja. Iako su tržišta više povezana nakon krize, još uvijek postoje mogućnosti za diverzifikaciju.

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Table 7. *Volatility transmission* (pre-crisis)*

$s^2_{t(France)} = 0.011 + 0.929s^2_{t-1(France)} + 0.080r^2_{t-1(UK)}$
$s^2_{t(Germany)} = 0.010 + 0.048e^2_{t-1(Germany)} + 0.926s^2_{t-1(Germany)} + 0.031r^2_{t-1(UK)}$
$s^2_{t(Italy)} = 0.021 + 0.923s^2_{t-1(Italy)} + 0.053r^2_{t-1(UK)}$
$s^2_{t(Spain)} = 0.022 + 0.925s^2_{t-1(Spain)} + 0.059r^2_{t-1(UK)}$
$s^2_{t(UK)} = 0.020 + 0.071e^2_{t-1(UK)} + 0.906s^2_{t-1(UK)}$

**All results are obtained in EViews*

Table 8. *Volatility transmission* (post-crisis)*

$s^2_{t(France)} = 0.040 + 0.103e^2_{t-1(France)} + 0.912s^2_{t-1(France)} - 0.021r^2_{t-1(Italy)}$
$s^2_{t(Germany)} = 0.022 + 0.057e^2_{t-1(Germany)} + 0.933s^2_{t-1(Germany)}$
$s^2_{t(Italy)} = 0.058 + 0.037e^2_{t-1(Italy)} + 0.915s^2_{t-1(Italy)} + 0.046r^2_{t-1(Germany)}$
$s^2_{t(Spain)} = 0.053 + 0.037e^2_{t-1(Spain)} + 0.907s^2_{t-1(Spain)} + 0.057r^2_{t-1(France)}$
$s^2_{t(UK)} = 0.047 + 0.075e^2_{t-1(UK)} + 0.883s^2_{t-1(UK)} + 0.040r^2_{t-1(France)} - 0.023r^2_{t-1(Italy)}$

**All results are obtained in EViews*

In the post-crisis period, German market volatility spills over to the Italian market. However, the results show that there is no transmission from other markets to Germany. French market volatilities spill over to the Spanish and UK markets. Italian market volatilities spill over to the French and UK markets, but the influence is inverse. Finally, it is also important to note that Spanish and UK market volatilities do not spill over to other markets. Also, volatility spillovers are unidirectional: Volatility from French market transmits to Spain, but there is no spillover from Spain to France.

CONCLUDING REMARKS

This paper investigated the volatility persistence and volatility spillovers among five major European countries (France, Germany, Italy, Spain and UK) from August 30, 2002 to August 31, 2007 and December 31, 2009 to December 31, 2015. GARCH (1, 1) and EGARCH (1, 1) were used to daily returns on country ETFs to study volatility persistence and Augmented GARCH for volatility transmission.

The highest volatility in the pre-crisis period was exhibited by Germany and France, and the lowest by Italy. In the post-crisis period Italian market exhibited the highest volatility, and UK market had the lowest volatility. The study of volatility persistence found that in the short run, the UK market is spikey but volatilities do not persist very long (pre and post crisis). On the other hand, results showed that Germany (pre and post-crisis) is not volatile in the short run but a long term effect of past shocks on returns is the strongest among selected countries and at the same time those effects of the volatility shocks persist very long.

Presented EGARCH (1, 1) results showed that investors are more sensitive to the negative news in the post-crisis period. EGARCH (1, 1) provided a better fit for all markets in the post-crisis period.

The findings of volatility transmission in the pre-crisis showed that UK is the only market not experiencing volatility spillovers from other markets, but on the other hand volatility from the UK market transmits to all other analyzed markets. These results are in line with the findings of Xiao and Dhesi (Xiao, Dhesi, 2010). Post-crisis, the results showed that there is no volatility transmission from other markets to German market. Also, Spanish and UK market volatilities do not spill over to other markets. French market volatilities spill over to the Spanish and UK markets. Finally, in the post crisis period there was an inverse influence of Italian market volatilities on the French and UK market volatilities.

Eurozone countries are much more correlated after the crisis. Also, Eurozone countries are more correlated with the UK after the crisis. Data on volatility persistence and volatility transmission can be very useful for portfolio managers and investors who want to efficiently diversify their portfolios. Even though markets are more correlated after the crisis there are still opportunities for diversification.

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