BACHAR FAKHRY

Behavioural Finance

Reviews on EuroZone and Brexit

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Behavioral Finance - Reviews on EuroZone and Brexit

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Preface

After five years of research into the hot debated and my chosen topic of behavioural finance, it has become obvious that the field is a major area of studies. Over the years I have tried to provide empirical evidence that markets do tend to follow trends set by theories of behavioural finance. The evidence I presented surround the key events since the millennium; events such as the introduction of the euro, the global financial and eurozone sovereign debt crises and Brexit. As can be seen from these events, I have tended to mainly concentrate on the reaction of market participants in the European Union.

i. *The Introduction of the Euro and Eurozone Financial Markets Integration*

The introduction of the euro was and still is one of the financial events of the last few decades. I was working as a software engineer at IBM at the time, the topic of the day was how will the introduction of the euro effect the transactions of many financial institutions. By the mid-2000s, I was doing an MSc in financial Management and decided to do my dissertation on the euro. By then the Euro has established itself as one of the major currencies and many thought it would challenge the US dollar. However, by the end of the 2000s the tide was beginning to turn as the weaknesses of the European monetary union were highlighted first by the recession which followed the financial crisis and then the sovereign debt crisis. These events led to a rise in nationalist tendencies across the eurozone. Funnily enough while I was writing my paper which forms chapter of this book, a dear friend and old lecturer of mines suggested I call it Happy 20th Anniversary Euro: from shining beacon of hope to ticking time bomb.

ii. *The Global Financial and Eurozone Sovereign Debt crises*

In 2007, I had a job interview with Lehman Brothers which I didn't get the job. Just one year later, at the height of the global financial crisis, Lehman Brothers were in financial difficulties leading to the biggest bankruptcy. I knew that the asset market including the housing market was overpriced. I remember watching a Robert Peston (a BBC News Chief editor and Reporter on Economics at the time) current affair tv programme on the US Mortgage crisis in mid-2007. So, I knew about the underlying causes of the financial crisis, but little did I know what would eventually happen. The financial crisis was not unpredictable when you know what to look for but what took most people by surprise was the depth and length of it, I suspect. The sovereign debt crisis came at a time when I was preparing to do my PhD in a way, it came at the right time for me. I was able to focus my research on the reaction of market participants in the sovereign debt markets firstly concentrating on the efficiency of the market and later on the behaviour of market participants. To my mind, the financial and Eurozone crises were a lesson in how not to handle crises.

iii. *Brexit*

Brexit was the result of a misunderstanding of the extent of nationalist feeling and economic division across Europe. It just so happens to have occurred in the UK, the most outsider of all the European Union member states. Once again it was a lesson in how not to handle an event. The major issue is that government did not learn the lesson of the financial and sovereign debt crises. My own personal belief is that the UK should not have held a referendum about such a complicated issue and one that has the potential to affect the lives of every British citizen for the long run in the first place. However, now that the Brexit is a happening, IK think the UK government was wrong to rule out a soft Brexit at the start of the process.

In all these events it is hard not to include behavioural finance in analysing the impact on the financial markets. The key in all this is the feedback effect between the actions of the market participants and governments (or the EU).

B. Fakhry
December 10, 2019

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1 A literature review of behavioural finance

Introduction

In essence, this paper is a study of the theories influencing the asset pricing in the global financial market. In order to understand asset pricing, we must understand the influencing factors underpinning the two fundamental theories of asset pricing: the efficient market hypothesis and behavioural finance theory. As proposed by Malkiel (1962) and Fama (1965), the efficient market hypothesis argues that the price of any asset must immediately reflect fundamental information about the asset. Whereas the behavioural finance theory, as argued by Statman (2008) and Subrahmanyam (2007), states that in order to truly understand the movement of asset prices there is a requirement to include the psychology of the market participants.

Essentially, as stated by De Bondt (2000), there are three perspectives on asset pricing: “the price is right” view proposed by Malkiel & Fama (1970), the price is driven by animal spirit view of Keynes (1936) and any uptrend in an asset price must eventually come down resembling Newton's law of universal gravitation. Interestingly the third perspective is the key to understanding the empirical studies of behavioural finance. Some of the issues regarding the pricing of assets cannot be addressed without a reference to the behavioural finance theory. A criticism (for example De Bondt et al. (2008) and Kourtidis et al. (2011)) often put against the neoclassical economics model and in particular, the efficient market hypothesis is that market participants are homo-sapiens and not homo economics. Hence, in order to address these issues there is a requirement to understand the psychology of the market participants. This led to the alternative theory of behavioural finance being put forward by Statman (2008) and Subrahmanyam (2007) amongst others. A key notion in behavioural finance theory as put by Bernard Baruch is:

> "What is important in market fluctuations are not the events themselves, but the human reactions to those events." (Lee *et al.*, 2002, p. 2277).

One of these issues is the price deviation from the fundamental value. As the comment from Bernard Baruch above hints, the key to understanding this deviation is the reaction of the market participants. This lends itself to the overreaction hypothesis as suggested by Barberis et al. (1998), Daniel et al. (1998), Hong & Stein (1999) and De Bondt (2000). This leads to another issue, the existence of bubbles, which causes the asset price to temporary deviate from the fundamental value in the short to medium term as illustrated by Kindleberger & Aliber (2005).

This paper will open with brief overview of the behavioural finance theory. This will be followed by an in depth review of the overreaction/underreaction hypothesis before continuing on to rational bubbles. The final part is the conclusion.

The Theory of Behavioural Finance

In essence, De Bondt *et al.* (2008) and Kourtidis *et al.*(2011) argue that there is a necessity to understand the psychology of market participants in order to provide an explanation of market abnormalities, such as asset price bubbles and crashes, and comprehend the efficiency of the financial markets. This would seem to suggest it is difficult to fully understand and research the global financial market without reference to the behavioural finance theory. In addition, as hinted by Kourtidis *et al.* (2011), the obvious existence of irrational market participants making random transactions in the market can only be adequately explained by taking account of behavioural factors. As stated by Barberis & Thaler (2003), the impact on the price from these irrational market participants can be long-lived and substantial. According to Barberis & Thaler (2003), these two issues (i.e. the psychology and the long-lived impact of irrational market participants) form the building blocks of behavioural finance.

As stated by Kourtidis *et al.* (2011), whereas traditionally financial theories examine how people behave with respect to wealth maximization, behavioural finance is interested in how people "*actually*" behave in a financial environment. Essentially, as defined by De Bondt *et al.* (2008) and Statman (2008) behavioural finance is the psychological study of the market participants and their interaction with the financial markets where the market participants may be individual households or organizations. As stated by De Bondt *et al.* (2008) the behavioural finance theory is not necessarily based on the assumption of rational market participants and efficient markets. An important factor in the behavioural finance theory, indicated by Statman (2008), is that market participants are assumed to behave normal in the sense that they act rational but with a limited information set. As a result, markets are not efficient but hard to beat. The main idea influencing the behavioural finance theory is a number of behavioural factors influences market participants, to fully understand this reaction of market participants there is a need to research these behavioural factors. Kourtidis et al. (2011) state there are many behavioural factors highlighted in the literature on behavioural finance that explain the behaviour of market participants in the financial market. However, they limit their study to four major behavioural factors in analysing the market participants' behaviour in the financial market: over-confidence, risk tolerance, social influence and self-monitoring.

According to Subrahmanyam (2007) there seems to be evidence to suggest that the assumptions and models underpinning the behavioural finance theory are plausible. He states there is evidence to suggest that non-risk based factors influence the predictions of returns more than risk-based factors. There also seem to be evidence to suggest that psychological hypothesises about market participants' biases can be tested in an ex-ante manner. And although the evidence seems to be suggesting that markets are inefficient and predictable patterns do exist, this does not mean that individual market participants can make large excess returns. However, there is evidence that institutional market participants are able to take advantage of these predictable patterns in the financial markets. He argues that although there is evidence suggesting that irrational agents do influence the market in the short run, however there is also strong evidence that irrational agents do influence the market in the long run.

As hinted by Subrahmanyam (2007), there is evidence to suggest that asset prices are influenced by a reference price and the disposition effect. This evidence seems to be pointing towards the existence of a pattern in the trading activity of individual market participants. Moreover, as he hints although there is evidence to suggest that market participants seem to be constructing their portfolios from a limited number of simple strategies like locality, knowledge and word of mouth. However, there seem to be a lack of emphasis in the literature on portfolio choice of market participants. Another key factor as stated by Statman (2008) is that the hypothesises underpinning the behavioural finance theory, such as the disposition hypothesis which predict market participants will realize rapid gains but defer losses, are testable. Thus meaning they can be rejected or accepted depending on the analysis of the data and have been shown by many empirical studies to be capable of accurately predicting market participant's behaviour.

The Overreaction/Underreaction Hypothesis

A key assumption of the efficient market hypothesis is that current prices should fully reflect all information on the asset as hinted by Fama (1965) and Malkiel (1962). There is an issue with this statement in that the current price does not reflect the information but the sentiment of the market participants with respect to the information as suggested by De Bondt (2000) and Daniel *et al.* (1998) among others. Therein lays the key to understanding the overreaction hypothesis (as hinted by Barberis et al. (1998), Daniel *et al.* (1998), Hong & Stein (1999) and De Bondt (2000)); since market participants have different perspectives on how to interpret the new information, therefore the price could deviate from the fundamental value. Essentially, as hinted by De Bondt (2000), the overreaction hypothesis states that sometimes market participants tend to disproportionately react to information (fundamentals and news) causing a temporarily and dramatic deviation from the fundamental value. Usually the price does revert to the fundamental value within a short period of time as market participants digest the information.

In essence, according to De Bondt (2000), most overreactions are due to errors in market participants' forecasts. A common issue is that market participants are often upbeat during bull markets and gloomy during bear markets, this is reflected in their perspectives of the asset price. Another issue is the problem of overestimation of the information on the asset during the issuance or initial public offering stage by the agents. According to Barberis *et al.* (1998), a key factor in the overreaction hypothesis is that a sequence of good or bad news can lead to an overreaction by market participants assuming the continuation of the trend. Daniel *et al.* (1998) suggest there is a differentiation based on whether the information is public or private. Thus meaning market participant are overconfident in their private information leading to an overreaction in the market. Whilst in general they tend to underreact to public information. Moreover, as discussed in Barberis *et al.* (1998) the evidence seems to be pointing at some market participants' conservative attitude to updating their model incurring the underreaction hypothesis.

However, as Hong & Stein (1999) highlight it is essential to analyse the interaction between heterogeneous market participants. They analyse two types of bounded rational market participants: momentum traders and news watchers to illustrate the effects on one another. The results seem to be suggesting that when news watchers pick up new information, in general they underreact. This is mainly due to the gradual diffusing of information and the assumption that they do not observe prices. When short run momentum traders enter the market, seeing a chance to profit, instead of pushing the price towards the fundamental value, they cause an overreaction to any news. While in the short run market participants could make a profit, in the long run they make losses due to the price exceeding the long run equilibrium price. According to Hong & Stein (1999), the inclusion of well-informed fully rational arbitrageurs does not eliminate the effects of other less informed and rational market participants. Thus meaning the overreaction continues to have an impact on the price.

Recent empirical evidence paints a mixed picture for the overreaction/ underreaction hypothesis, in Spyrou *et al.* (2007) they find a split between large and small capitalization stocks in the London Stock Exchange. Large capitalization stocks were consistent with the efficient market hypothesis, while medium to small stocks seem to underreact to news shocks for many days. This underreaction is unexplained by risk factors or any other known effect.

A relevant factor raised by Fakhry & Richter (2015) and Fakhry *et al.* (2016) regarding the efficient market hypothesis is that during some highly volatile periods some markets seem to be rejecting the null hypothesis of the market being too volatile to be efficient. As hinted by Kirchler (2009), the underreaction/ overreaction hypothesis provides one possible explanation, which suggests that market participants' reaction leads to overvaluation or undervaluation during bulls or bears market respectively. Hence, a highly volatile period with instances of both a bear and bull market would give the impression of an efficient market.

However, contrary to the two previous articles, Lobe & Rieks (2011) find significant evidence of short-term overreaction in the Frankfurt stock exchange is not limited to small capitalization stocks. The explanation seems to be in the anomalies and stock characteristics. However, transaction costs and unpredictable markets mean that market participants may not be able to exploit these effects. This means that due to the unforeseeable direction of the reaction and the existence of transaction costs prohibiting the implementation of consistent profit making strategies, they conclude the evidence seem to be suggesting no violation of the efficient market hypothesis.

A Review of the Effects of Rational Bubbles

Essentially, as hinted by Barlevy (2007) the popular notion is bubbles are initiated by rapid upwards pressures on the price of a particular type of asset or index in a short interval of time, eventually causing downward pressures to correct the price or more dangerously a collapse in the price. In simple terms, as hinted by Blanchard & Watson (1982), a popular notion defines a bubble as a price deviation from the fundamental value that is apparently unjustified by the information available at the time. This was evidence in the technology boom of the late 1990s to early 2000s and housing market boom of the early to mid-2000s. As illustrated by Kindleberger & Aliber (2005), history is filled with such episodes, the first recorded bubble often referred to as the Dutch tulip bubble of the 1630s, the South Sea Company bubble of 1719-1720 and the US stock market bubble of the 1920s, which ended with the Wall Street crash of 29th October 1929.

However, as Barlevy (2007) argues this popular definition is ambiguous about the scale and length of time of a bubble. At the heart of this argument is the fact large price swings could occur under normal market conditions due to shifts in supply and demand. An example is an asset with cyclical changes in demand, therefore causing dramatic price changes. These price changes are sometimes known as fads. In essence, as Barlevy (2007) states many economists define a bubble as a rapid upwards deviation from the fundamental value.

As noted by Blanchard & Watson (1982), therein lays the difference between economists and market participants. Economists believe that any deviation from the fundamental value is evidence of irrational behaviour whereas market participants believe extraneous events could influence the price of any asset or index. In other words, "crowd psychology" is an important element in the behaviour of asset pricing as pointed by Blanchard & Watson (1982). And as Brunnermeier (2001) highlights, there is empirical evidence provided by Shiller (1979) among others of excess volatility in asset prices meaning prices deviate from their fundamental value more than predicted by the efficient market hypothesis. This evidence would suggest there could be rational deviation from the fundamental value i.e. rational bubbles. Rational bubbles appear in asset prices

> "If market participants are willing to pay more for the stock than they know is justified by the value of the discounted dividend stream because they expect to be able to sell it at an even higher price in the future, making the current high price an equilibrium price" as defined by Gurkaynak (2008, p. 166).

Furthermore, as Blanchard & Watson (1982) point rational behaviour and expectation does not imply that prices must follow fundamental values. Of course, there is some evidence of irrational behaviour in the market that could cause irrational bubbles for a survey of this type of asset price bubbles see Vissing-Jorgensen (2004).

As stated by Abreu & Brunnermeier (2003), the efficient market hypothesis implies that bubbles do not exist by virtue of the existence of rational well informed and financed arbitrageurs guaranteeing that any potential mispricing will be corrected (Fama, 1965). However, as Abreu & Brunnermeier (2003) argue some rational arbitrageurs also like to take advantage of the bubble to further their earnings while the bubble last, hence ideally leaving the market just before the crash. Nevertheless, since each rational arbitrageur have their own model and assumption of when to leave this leads to asymmetrical information and different viewpoints. The key argument against the assumption of the existence of rational and financed arbitrageurs is this incoordination between the very agents that will supposedly correct any mispricing in the assets. Moreover, as Abreu & Brunnermeier (2003) illustrate many supposedly rational agents have lost out on huge profits or made huge losses by mistiming their exit. As exemplified by the different cases of Julian Robert, Tiger Hedge Fund, and Stanley Druckenmiller, Quantum Fund, during the tech bubble of the late 1990s early 2000s see Abreu & Brunnermeier (2003, p. 175).

Conclusion

In concluding, it is hard to explain the recent financial and to a certain extent sovereign debt crises without referring to the behavioural finance theory. In essence, the psychology of humans dictates that under normal conditions each market participant would interpret the given information about a financial asset differently. The nature of financial crises is such that information becomes increasingly asymmetrical and news has a greater impact than fundamentals. Hence, as illustrated throughout this section, there is ample evidence suggesting that financial markets are governed by the reaction of market participants to events such as De Bondt *et al.* (2008), Kourtidis *et al.* (2011) and Lee *et al.* (2002). Another factor highlighted by Bernanke (2010) and Barberis (2011) is the possibility of increases in asset prices beyond the fundamental value dictated by the information over a period. These two factors point to the existence of asset price bubbles and overreaction hypothesis influencing the behaviour of prices and hence volatility.

As illustrated earlier, evidence in the financial markets suggest a mixed picture for the overreaction hypothesis see Spyrou *et al.* (2007), Kirchler (2009), Lobe & Rieks (2011) and recently Fakhry & Richter (2015) and Fakhry *et al.* (2016). On the other hand, the evidence seems to suggest that market participants do react to certain extreme events such as the 11 September 2001 terrorist attacks, Lehman Brothers Bankruptcy and the Japanese tsunami of 2011. This seem to be explained by Knightian Uncertainty which dictates under certain market conditions market participants are faced with immeasurable systemic risks which lead to market participants overreacting as hinted by Caballero & Krishnamurthy (2008). In essence, this evidence seems to be suggesting that it is news and not fundamentals influencing the financial markets during any financial crisis. In addition, the overreaction/underreaction hypothesis may provide a part of the explanation for the asset price bubbles.

There is ample evidence throughout history of asset price bubbles, yet a fundamental weakness of the efficient market hypothesis is its assumption that bubbles cannot exist due to the existence of rational well-informed and financed arbitrageurs see (Fama, 1965). However, as illustrated earlier in this section, there is a hint of catch 22 for these arbitrageurs that lead to huge losses or miss-opportunities see (Abreu & Brunnermeier, 2003). This highlights the difficulties of planning strategies during episodes of asset price bubbles, since it is very difficult to know when an asset price bubble will burst. The problem is complicated by the existence of mixed evidence in the detecting of asset price bubbles see (Gurkaynak, 2008).

In concluding, behavioural finance is an essential theory in the explanation of the behaviour of asset prices. This is highlighted by the existence of homo-sapiens in the global financial market as the decision makers. In essence, neoclassical economics and the efficient market hypothesis do not explain certain types of behaviours in the financial market such as asset price bubbles and market participants' reactions to news or information. However, the mixed empirical evidence, especially in the case of testing for asset price bubbles and to a lesser extent the overreaction/underreaction hypothesis, seem to be pointing towards a lack of econometrical tests and understanding of how market participants react to certain events and information.

In concluding, the efficient market hypothesis and behavioural finance theory explain different parts of asset pricing. However, as things stand at present, both have strong weaknesses. This means in order to understand the pricing of assets there is still a requirement to use both fundamental theories. Coincidentally, the behavioural finance theory could be extended to explain the efficient market hypothesis by using the overreaction/underreaction steady state and the key is that this is testable. So in essence the behavioural finance theory is a more complete and therefore theoretically superior theory of asset pricing.

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2 A literature review of the efficient market hypothesis

Introduction

The dominant asset pricing theory since the early to mid-1960s have been the efficient market hypothesis, developed through the contributions of prominence articles such as Malkiel (1962), Fama (1965) and Malkiel & Fama (1970). As proposed by Malkiel (1962) and Fama (1965), the efficient market hypothesis argues that the price of any asset must immediately reflect fundamental information about the asset. However, to a certain degree the efficient market hypothesis relies on some untestable assumptions and models. Yet it is possible to test the key assumptions of random walk and efficiency individually thru the use of prominent tests like the variance ratio and bound tests proposed by Lo & MacKinlay (1989) and Shiller (1981) respectively.

At the basic level, the efficient market hypothesis is the perfect competition, which is widely used in neoclassical economics. Perfect competition implies the assumption that market participants are rational, risk averse and profit maximising. This assumption of market participants' behaviour extends to the efficient market hypothesis, as proposed by Fama (1965) and Malkiel (1962). This highlights the needs to evaluate the assumptions influencing the behaviour of market participants under uncertainty before we can research the efficient market hypothesis.

The paper will open with a brief overview of the fundamental economic paradigm underpinning the efficient market hypothesis, namely neoclassical economics. This will be followed by an in depth review of the efficient market hypothesis before concluding.

Neoclassical Economics

Historically, neoclassical economics have been the dominant view in explaining the behaviour of financial markets under uncertainty. In essence, this view dictates that rational market participants should follow the key assumptions of profit maximization, Friedman (1953) and Alchian (1950), and risk aversion, Pratt & Zeckhauser (1987) and Kimball (1993), in their choice of investment. The key in understanding this argument is the negative correlation effect that the assumptions of profit maximization and risk aversion have on financial asset prices. This view has been criticised by many including proponents of the theory of behavioural finance such as Freeman *et al.* (2004) and Kourtidis *et al.* (2011). The key problem is the assumptions underpinning the view, are unrealistic, for example rational agents as explained by De Bondt *et al.* (2008) and stockholder theory as argued by Philips (1997). In this section, we critically review the neoclassical view concentrating on the arguments influencing the assumptions of profit maximization and risk aversion.

However, since financial institutions with stockholders, dominate the sovereign debt market; it is necessary to discuss the stockholder theory. The stockholder theory dictates that businesses only exist to maximize the stockholders' wealth within the rule of the law; and as Alchian (1950) and Friedman (1953) hints this means the realization of profits; put simply as Alchian (1950, p.213) states:

> "This is the criterion by which the economic system selects survivors: those who realize positive profits are the survivors; those who suffer losses disappear."

This is also argued by Friedman (1953, p.22)

> "Whenever the determinant happens to lead to behavior consistent with rational and informed maximization of returns, the business will prosper and acquire resources with which to expand; whenever it does not, the business will tend to lose resources and can be kept in existence only by the addition of resources from outside."

However, as many proponents of the stakeholder theory (such as Freeman *et al.* 2004; Philips *et al.*, 2003; Philips, 1997 and Hosseini & Brenner, 1992) would point out there is more to business ethics than just profits. The idea as defined by Jensen (2002) is that businesses have to take into account the interests of all stakeholders in the firm. By definition stakeholders includes all individuals and groups who can affect the welfare of the business and not just shareholders. However, Friedman (1970) argues that the only social responsibility for a business is to increase its profit.

This seems to be suggesting that as dictated by the market selection hypothesis in order for the financial institutions to survive, there is a need to attract investment funds and thus generate huge profits as hinted by Dutta & Radner (1999). The problem is that the behaviour of many of these financial institutions during the assert price boom of the mid 2000s points towards pure profit maximization. As defined by De Scitovszky (1943), pure profit maximization is the constant shifting of profit targets to maximize the utility function of the shareholders. In contrast, the key argument of Alchian

(1950) and Tintner (1941) is that businesses just have to make a positive profit to survive. The key point is, if they make losses they struggle to survive as hinted by many including Alchian (1950) and Friedman (1953). A point in case is the bankruptcy of Lehman Brothers and hence the government bailout of many financial institutions during the financial crisis.

In a way this led to the accusations by many including government inquiries[1] into the crises of financial institutions being too risk loving and greedy. However, the point defined by Kimball (1993), standard risk aversion follows a marginal increasing function, which means that bearing one risk makes the market participant less willing to bear another risk. Another argument highlighting this is that increasing risk leads to an upward shift in risk aversion as noted by Diamond & Stiglitz (1974). This seems to be the overwhelming behaviour during the recent financial and sovereign debt crises. A counter argument is that market participants' behaviour seems to be following proper risk aversion. As defined by Pratt & Zeckhauser (1987), proper risk aversion dictates that with respect to two independent risks, the rejection of one risk does not automatically deflect the market participants from taking the other independent risk. This is mainly due to market participants hedging their risks by the use of derivatives instruments such as options and futures. An example is the use of credit default swaps as hedges against the risk of a government defaulting on its debts. However, a key point made in Alchian (1950) definition above is that companies that make losses do not survive and this highlights an alternative argument that many market participants display loss aversion rather than

[1] Such as the House of Commons Treasury Committee Report Number 416 in the UK and Financial Crisis Inquiry Commission Report of January 2011 in the US.

risk aversion. As defined by Kahneman *et al.* (1991) and Thaler *et al.* (1997), loss aversion dictates that market participants tend to be increasingly sensitive to a loss than to a gain or put simply the feedback effect. This is obvious from the reaction of the financial institutions during the sovereign debt crises where a loss made the institutions averse to any further losses. This meant that the crises quickly spread from Greece to other sovereign debt markets.

This leads us to the utility functions of the agents, since these agents caused the problems as often cited by government inquiries into the crises (see footnote 4). Given an option between a number of similarly risky investments, utility maximization theories dictate that the agent choses the one with the highest income. However, in a situation where the agents of financial institutions face investments of different risks, the key question is how can they choose the investment, which maximizes their utility? This problem occurs if interest rates are low and banks therefore take on larger risks for a higher return. This has resulted in the development of a sub-prime mortgage market, for example, where prices no longer reflect the risks, which ultimately led to the collapse of the market. The collapse occurred despite the existence of derivatives instruments such as CDS to insure against that risk. Surely, this would conflict with the utility maximization behaviour of buying risky securities such as subprime mortgage securities. Still, this behaviour can be justified as rational, when one takes into account an S-shaped utility curve. Friedman & Savage (1948) and Hartley & Farrell (2002) argue the possibility of non-concave or non-diminishing marginal utility function leads to different behaviour towards risk. This could explain the rational behaviour of the huge gamble taken by the agents during the recent housing and mortgage backed securities prices bubble. So in essence, the argument is that even efficient markets can lead to market instabilities. As the crisis has shown, however, many market participants did not actually know what they were buying as illustrated by (Beltran & Thomas, 2010; Brunnermeier, 2009; Gorton, 2008). Therefore, the validity of this argument is questionable in the least.

However, as argued by Pennings & Smidts (2003) the evidence points towards an S-shaped utility function curve governed by the agent's attitude towards profit and loss, in other words, the shape of the utility function depends on the initial situation, which is not compatible with rational behaviour. As this makes the utility function unstable resulting in higher volatility of observed bond prices, as buying and selling of bonds depended on the changing utility function. So in essence, the argument is that even efficient markets can lead to market instabilities.

The utility function of the agents in the financial sector dictates the supply and demand model is the reverse of the standard model as suggested by Cifuentes *et al.* (2005) and Shin (2008). And as hinted by Shin (2008), this means under profit maximization behaviour demand in high return assets increase putting upward pressures on the equilibrium price, while risk aversion behaviour not only reverses the demand for high return assets, due to the high risk associated with these assets, but also increases supply leading to a decrease in the equilibrium price. The sovereign debt crises elegantly illustrated this, in the high demand environment of the flight to liquidity or quality during the financial crises; governments were able to control the increase of demand by issuing more debt. During the sovereign debt crises demand for several sovereign debts decreased hugely but the point here is, the supply also increased putting huge downward pressures on the prices. The reasons are simple unlike the standard model of supply and demand which dictates when prices go down the issuer could reduce the supply to ease the pressures on the equilibrium price. The existence of a secondary market meant that as market participants became increasingly risk averse due to a high possibility of defaults, they sold the debts meaning the secondary market became overstocked and the prices plummeted. So no matter what the governments of the GIPS nations or the Eurozone tried to do, they could not reduce the supply and hence the yield.

As hinted previously, an argument often used against the neoclassical economics is that market participants are not all rational as suggested by Hong & Stein (1999) and Kourtidis *et al.* (2011). In addition, unlike the assumption dictating that the impact on the prices from irrational market participants is short-lived, the evidence from Barberis & Thaler (2003) is that the impact is long-lived. The other issue concerning neoclassical economics is that the basis for many of the simplifying assumption of the models is that all market participants exhibit rational risk averse profit maximisation behaviour. As with the previous argument, the existence of heterogeneous market participants each with a different attitude to risks and earnings means that this assumption of homogeneous behaviour regarding risks and earnings does not hold. In this case, we need to use behavioural finance theories to identify the impact of heterogeneous market participants in different circumstances as illustrated by Hong & Stein (1999).

The Efficient Market Hypothesis

Before we can start reviewing the efficient market hypothesis, there is a need to define information in the context of this research. Although as hinted by Malkiel & Fama (1970) and Malkiel (2003), the efficient market hypothesis dictates that prices should reflect all available information (which is why we use prices rather than spreads to check for market efficiency in this thesis). It is common practice to distinguish information in terms of fundamental and non-fundamental information (Bollerslev & Hodrick, 1992). In other words, information is the summation:

- the fundamentals, such as yields or macroeconomic factors in the sovereign debt market, as hinted by Cochrane (1991) and Malkiel (2003),
- non-fundamentals, such as information from news (i.e. they do not have any direct relationship to the asset but still have the power to influence the price such as the 9/11 terrorist attacks, Lehman Brothers bankruptcy in 2008 and Japanese Earthquake in 2011), as hinted by Caballero & Krishnamurthy (2008).

Malkiel & Fama (1970) notes simply put the efficient market is a market where market participants are assumed to exhibit rational profit maximization behaviour and prices always fully reflect available information. In essence, as Malkiel (2003) states the view influencing the efficient market hypothesis is information spreads quickly and priced into asset valuation immediately. Hence, as Malkiel (2005) states this means that no arbitrage opportunities exist that allows for excess returns without excess risks. As Malkiel (2003) hints in an efficient market, competition will mean that opportunities for excessive risk adjusted returns will not persist. However, this does not mean that the efficient market hypothesis imply market prices will always be accurate and all market participants will always exhibit rational profit maximization behaviour.

According to Malkiel & Fama (1970), the efficient market hypothesis dictates that any model of expected price should follow the notation of $E(\tilde{p}_{j,t+1}|\phi_t) = [1 + E(\tilde{r}_{j,t+1}|\phi_t)]p_{jt}$. The importance of this equation in the concept of this research is ϕ_t. According to Malkiel & Fama (1970), this suggests that the expected price based on all available information at present is the price at present plus the expected return based on all available information at present. As Malkiel & Fama (1970), states this notation of the expected price, means regardless of which model (e.g. APT or CAPM) used to derive the equilibrium price, expected return should fully reflect all information available at present, transaction costs and taxations being equal. Remember, as noted by Malkiel & Fama (1970), where expected excess value or return on the asset is equal to zero then by definition the excess value or return is a fair game with respect to the information available. In essence as quoted by Malkiel (1962), the expectation of the future price of the asset strongly influences the price of any long-lived asset. However, as put by Malkiel (1962), it is plausible that the recent past dictates the market participants' expectations.

As suggested by both Fama (1965) and Malkiel (2003), the efficient market hypothesis is associated with the idea influencing the random walk model. A big issue with regard to the pricing of information, as seen in numerous events during the recent financial and sovereign debt crises, is nobody can predict the impact of information especially under uncertainty. Hence, as Fama (1965) states during periods of uncertainty the equilibrium price can never be determined exactly. Moreover, as hinted by Fama (1965) the instantaneous adjustment property of the efficient market hypothesis may cause successive independent price changes, which imply prices follow the random walk model. As defined by Malkiel (2003, p.59)

> "The logic of the random walk idea is that if the flow of information is unimpeded and information is immediately reflected in stock prices, then tomorrow's price change will reflect only tomorrow's news and will be independent of the price changes today."

Although, as stated by Malkiel & Fama (1970), the random walk model does not state that past information has no value in assessing distribution of future returns. However, the random walk model does state that the sequencing of past returns has no value in assessing distribution of future returns. This last statement could infer the random walk model simply put is the direction in the short run of expected returns and hence prices is unpredictable given all available information; however, in the long run the trend in the market prices is partially predictable as stated by Malkiel (2005). Furthermore, as stated by Timmermann & Granger (2004), this makes the efficient market hypothesis notoriously difficult to forecast prices and returns. The key logic behind this is if prices and returns were forecastable, it would mean the existence of unlimited profit, which would make the economy unstable as noted by Timmermann & Granger (2004).

As hinted by Ball (2009), many in the regulatory, financial markets and academic environments were critical of the efficient market hypothesis in the aftermath of the financial crisis. The reasoning behind their argument boils down to the key notation underpinning the efficient market hypothesis that market prices should reflect all available information. This led to the false sense of security by regulators and market participants that market prices were correct based on all information leading to an asset price bubble. Ball (2009) argues that while like all good theories the efficient market hypothesis does have major limitations; however, appear to exaggerate the criticisms in the aftermath of the global financial crises. Since the theory of the efficient market hypothesis was only published by Fama (1965), this argument is invalid since there have been many crises based on the asset price bubble before the advent of the efficient market hypothesis. Ball (2009) points to the fact that the efficient market hypothesis states current asset prices are correct based on all available information; this means that market participants should accept asset prices as correct. However, in the pre-crises asset price bubble many market participants thought that asset prices were "incorrect" and hence they could beat the market. This does seem to suggest that for some market efficiency based on all information the price is right/correct. However, this is misleading, since the efficient market hypothesis, as defined by Malkiel & Fama (1970), does not state that the price is right/correct; it only states the price should reflect all available information.

A key argument often put against the efficient market hypothesis is that sometimes asset prices deviate from the fundamental value as hinted by many including Barberis & Thaler (2003) and De Bondt *et al.* (2008). In addition, as illustrated by Barberis & Thaler (2003) these deviations can be long-lived and substantial. Another issue raised by Hong & Stein (1999) is that market participants may not have access to all the information. And even if they do, as suggested by De Bondt (2000) and Daniel *et al.* (1998) they may have different sentiment about the information.

A key assumption used in the efficient market hypothesis is the existence of well-informed wealthy rational arbitrageurs who push the asset price back to its fundamental value (Fama, 1965). As Hong & Stein (1999) illustrate the existence of these arbitrageurs does not counter the effect of other market participants and Abreu & Brunnermeier (2003) argue that these arbitrageurs sometime like to take advantage of the circumstances therefore pushing the price further from the fundamental value.

Another key argument is that markets often go thru phrases where the efficient market hypothesis is not enough to explain the anomalies, e.g. bubbles (see Blanchard & Watson, 1982; Hong & Stein, 1999; De Bondt, 2000; Abreu & Brunnermeier, 2003). Hence, there is a need to research the psychology of market participants as suggested by De Bondt *et al.* (2008) and Kourtidis *et al.* (2011). This leads towards the use of the behavioural finance theory.

The evidence seems to suggest there is a link between the pricing of information and sovereign debt markets and as Brandt & Kavajecz (2004) hints there are two main mechanisms for the daily changes in yields on sovereign debts: flow of public information and price discovery.

However, as illustrated by the numerous empirical studies, the majority of the evidence is on the effect of macroeconomic information and the heterogeneous interpretation, known as price discovery, or public information. Christiansen (2000) argues that contrary to equity and corporate bond, in general there is no private information in sovereign debts returns. Thus, generally any movement in the returns on sovereign debts must come from public information, i.e. macroeconomic announcements and since the time varying return volatility of financial assets are autocorrelated and highly persistent, hence macroeconomic announcements could explain the high persistent observed in the volatility of sovereign debt markets. However, according to Greenwood & Vayanos (2010), macroeconomic variables sometimes cannot fully explain the variation in the yield curve and hence shifts in demand and/or supply of sovereign debts are other important drivers in understanding the movements in the yield curve.

According to Fleming & Remolona (1999), the key implications stemming from how public information influences the US Treasury market is the extent to which it drives the price movement and market makers are not confronted by imperfect information when trading. As implied by the article unlike many other financial markets, the treasury market being dominated by non-market based trading hence it is restricted by maximum or minimum limits on bid-ask spreads or price changes, therefore spreads and prices can adjust endogenously on public information. They identify two stages in the market's adjustment for price formation and liquidity provision in the immediate aftermath of the announcement of public information: during the brief first stage, there is a sharp and instantaneous change in prices and a reduction in the trading volume. During the next stage persistence trading surges leads to high price volatility and moderately wide bid-ask spreads.

Bollerslev *et al.* (2000) analysed the 5 min intraday US Treasury bond futures data over the period January 1994 to December 1997; researching long-memory volatility in macroeconomic announcements in the observed data. They found that US Treasuries futures exhibit long memory volatility in certain macroeconomic announcements. According to their research, the open and close of markets have higher volatilities than mid-day. The results indicate macroeconomic announcement is a key source of US Treasuries market volatility compared with prior results for FX and equity markets.

In an empirical study by Balduzzi *et al.* (2001) on the effect of regular macroeconomics news on a number of US Treasuries, the study found the greater the unexpected macroeconomic news announcement is, the more significant the impact on the price of at least one of the US Treasuries. They found that generally the price is usually the first affected by the announcement hinting that public information mainly drives the initial price adjustment. The next stage is the widening of the bid-ask spread suggesting informed trading drives both volatility and volume. The final stage is the continuation of the volatility and volume beyond the normality of the bid-ask spread hinting at liquidity trading. According to the article, different macroeconomic factors have different effects on the various securities. However, several announcements have significant impact on a number of securities and the impact varies depending on the maturity. They conclude that surprises in the announcement have a substantial impact on the price volatility but the bid-ask spreads seem to recover quickly hinting at public information being rapidly absorbed into the price.

In another empirical study by Brandt & Kavajecz (2004); show that price discovery is not necessarily concentrated around the time of the public information announcement. They imply at the existence of many factors influencing changes in the daily yield and therefore the structure of the yield curve but highlight two main complimentary factors: public information flow, such as periodically macroeconomic information releases, and heterogeneous interpretation of public information, i.e. price discovery, via trading in the Treasury market.

Interestingly, the Andersson *et al.* (2006) study of the effect of macroeconomic news from various countries on price discovery in the German long-term government bonds market finds that in general macroeconomic news have a stronger longer-lasting impact on volatility. In addition, they found that macroeconomic news from the US have more influence than the Eurozone announcements or various countries within the Eurozone.

An important aspect of market participants' behaviour as hinted by Caballero & Krishnamurthy (2008) is market participants face immeasurable systemic risks under certain market conditions, which lead to market participants exhibiting flight to quality or liquidity behaviour. Acknowledged as Knightian Uncertainty, it is believed to explain the behaviour of market participants in the aftermath of a wide range of events such as the Lehman Brothers Collapse in September 2008, Greek sovereign debt crisis and 9/11 terrorist attacks. The common factor is the lack of previous similar events to base information on. However, these events are based on news and hence as hinted by Malkiel (2003) news is by definition unpredictable resulting in price changes tending towards unpredictability and hence randomness.

In general, there is a large body of empirical literatures on the efficiency of the financial market. A large percentage of these are based on the stock market, the recent evidence on the efficiency of the stock market is mixed. Some found the stock market to be inefficient; an example is Cajueiro *et al.* (2009) who found the liberalization of the Greek stock market made it significantly less efficient. However, the evidence from Cuthbertson & Hyde (2002) seem to suggest the acceptance of the EMH for the French stock market and slightly less so for the German.

In comparison, the body of empirical literatures on the efficiency of the sovereign debt market is limited despite the first model of international efficient market being based on the French sovereign debt market as stated by Zunino *et al.* (2012). As Zunino *et al.* (2012) suggest the main reasons are the size of trading on the stock market and the type of trading for the sovereign debt market, mainly traded "over-the-counter". Like the stock market, the recent empirical evidence on efficiency in the sovereign debt market is mixed. Zunino *et al.* (2012) using sovereign debt indices found that developed markets tend to be more efficient than emerging markets.

Fakhry & Richter (2015) studying the impact of the recent financial and sovereign debt crises on the US and German sovereign debt markets found in general both markets were too volatile to be efficient. Although the US datasets do suggest the market is efficient, is efficient, yet the subsamples suggest a mixed results pointing to both crises having an impact on the efficiency of the US and German markets. Conversely, Fakhry *et al.* (2016) extending the method used in Fakhry & Richter (2015) to the GIPS markets, also find mixed evidence of efficiency during the crises. This leads to a possible explanation of the efficiency of the US datasets using the behavioural finance theory. Since market participants were overreacting/underreacting to information during different periods, one possible conclusion is that the overreaction/underreaction cancel each other out leading to a stable state in the datasets giving the impression of market efficiency.

Conclusion

The efficient market hypothesis has been the mainstream of finance for nearly 50 years. However, as highlighted in the review, there are many issues with this theory and it does throw up a basic flawed idea. The concept is that the price always incorporates all the information at the time and hence the price reflects the given information. This idea is at the centre of the debate surrounding the efficient market hypothesis in the aftermath of the financial crisis. The other key issue is that it relies on key assumptions made in neoclassical economics, which do not always hold in the real world, i.e. the existence of rational market participants and perfectly competitive markets. In truth, both the efficient market hypothesis and neoclassical economics view are essentially just models of the financial market and are therefore best used as benchmarks and not observations of the real world. A key factor to note is that market participants are homo sapiens and not homo economics.

Another issue as highlighted by Ball (2009), many were critical of the efficient market hypothesis in the aftermath of the financial crisis. The issue seems to be based around the price is correct argument, however this is dangerously misleading; since the efficient market hypothesis only states the price should reflect all available information at the time. There are two arguments regarding this issue; firstly, as highlighted by Ball (2009) in the pre-crisis period many market participants thought prices were incorrect and using sophisticated forecasting models, they could beat the market. Secondly, the efficient market hypothesis does not work when there is unequalled access to information resulting in incomplete or asymmetrical information. This goes back to the neoclassical economics assumption of perfect competition; in a perfectly competitive environment, information should be complete and accessible to all market participants.

Of course, a key neoclassical economics assumption is that market participants are risk averse. However, as hinted by Buiter (2007) and Feldstein (2007), as early as 2005 many thought there was massive under-pricing of risks. Hence, market participants were not following this fundamental assumption of neoclassical economics and thus the efficient market hypothesis. This goes to the heart of the problem during any asset price bubble, as illustrated in the next section, it is often the case that market participants usually think they could beat the market and therefore consistently under-price risk in the attempt of making increasingly large profits. Therefore, distorting the market from the fundamental price leading to increased asymmetrical information.

The key is determining whether the financial market accept the efficient market hypothesis, we presented strong historical empirical evidence suggesting financial markets are not efficient. The tests and methods used to test the efficiency of the markets in the empirical evidences are wide ranging, e.g. variance bound tests (Shiller, 1979), variance ratio tests (Lo & MacKinlay, 1988) and cointegration tests (Engle & Granger; 1987). Moreover, although the majority of the evidence seems to be based around the stock market, yet it does suggest that the global financial market is not random and asset prices are too volatile to be explained by the information. This is the key to our research, if markets are too volatile to be efficient then what is explaining the behaviour of volatility in the markets. Another key factor to our research as pointed out by Bollerslev & Hodrick (1992), the use of GARCH models can overcome clustering issues with the variance bound tests. A possible issue in the variance bound tests is that market participants seem to react differently to negative or positive information. In order to analyse whether markets are more efficient during phases of negative or positive shocks, there is a requirement to include the asymmetrical/leverage effect in the variance bound test.

In concluding, the efficient market hypothesis and behavioural finance theory explain different parts of asset pricing. However, as things stand at present, both have strong weaknesses. This means in order to fully understand the pricing of assets there is still a requirement to use both fundamental theories. Coincidentally, the behavioural finance theory could be extended to explain the efficient market hypothesis by using the overreaction/underreaction steady state and the key is that this is testable. So in essence the behavioural finance theory is a more complete and therefore theoretically superior theory of asset pricing.

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3 A regime switching explanation of the reactions of market participant during the crisis

Introduction

A criticism often put against the efficient market hypothesis is that market participants are homo-sapiens and not homo economics (De Bondt *et al.*, 2008 and Kourtidis *et al.*, 2011). Hence, in order to address this criticism there is a requirement to understand the psychology of the market participants. This led to the alternative theory of behavioural finance advocated by Statman (2008) and Subrahmanyam (2007) amongst others. A key notion in the behavioural finance theory as Bernard Baruch states:

> *"What is important in market fluctuations are not the events themselves, but the human reactions to those events"*
> as quoted by Lee et al. (2002, p. 2277).

As illustrated in Fakhry & Richter (2015) and Fakhry *et al.* (2016), one of the issues is the price tend to deviate from the fundamental value. As with the comment from Bernard Baruch, the key to understanding this deviation is the market participants' reactions. This lends itself to the overreaction / underreaction hypothesis as suggested by Barberis *et al.* (1998) and De Bondt (2000).

However, on some occasions there can be the appearance of multiple bubbles occurring over a short duration. This periodic collapse in a bubble can be analysed thru the use of a Markov process as alluded by Blanchard & Watson (1982), Evans (1991) and recently Branch & Evans (2011); this can be modelled by the use of the Markov Switching models (Hamilton, 1988). A related issue raised by Fakhry & Richter (2015) and Fakhry *et al.* (2016) is the reaction of the market participants seem to depend on the general market environment. Hence, we proposed using the SWARCH model of Cai (1994) to explain the reaction of the market participants during the recent financial and sovereign debt crisis as well as the pre-crisis period.

As we are analysing the possibility of using a regime-switching model to explain the overreaction and underreaction hypothesis, we start this paper with two short reviews of the overreaction//underreaction hypothesis and Markov regime switching ARCH models. The next section gives the methodology of the SWRCH model used. Section 5 and 6 presents the data and empirical results. Finally, section 6 concludes.

The Overreaction / Underreaction Hypothesis

A key assumption of the efficient market hypothesis is that current prices should fully reflect all information on the asset as hinted by Fama (1965) and Malkiel (1962). There is an issue with this statement in that the current price reflects the sentiment of the market participants with respect to the information as suggested by De Bondt (2000) and Daniel *et al.* (1998) among others. Therein lays the key to understanding the overreaction / underreaction hypothesis (as hinted by Barberis *et al.*,1998; Daniel *et al.*,1998; Hong & Stein, 1999 and De Bondt, 2000); since market participants have different perspectives on how to interpret the new information, therefore the price could deviate from the fundamental value. Essentially, as hinted by De Bondt (2000), the overreaction hypothesis states that sometimes market participants tend to disproportionately react to information (fundamental and news) causing a temporarily and dramatic deviation from the fundamental value. Usually the price does revert to the fundamental value within a short period as market participants digest the information.

In essence, according to De Bondt (2000), most overreactions are due to errors in market participants' forecasts. A common issue is that market participants are often upbeat during bull markets and gloomy during bear markets, this is reflected in their perspectives of the asset price. Another issue is the problem of overestimation of the information on the asset during the issuance or initial public offering stage by the agents. According to Barberis et al. (1998), a key factor in the overreaction hypothesis is that a sequence of good or bad news can lead to an overreaction by market participants assuming the continuation of the trend. Daniel *et al.* (1998) suggest there is a differentiation based on whether the information is public or private. Thus meaning market participant are overconfident in their private information leading to an overreaction in the market. Whilst in general they tend to underreact to public information. Moreover, as discussed in Barberis *et al.* (1998) the evidence seems to be pointing at some market participants' conservative attitude to updating the model incurring the underreaction hypothesis.

However, as Hong & Stein (1999) highlight it is essential to analyse the interaction between heterogeneous market participants. They analyse two types of bounded rational market participants: momentum traders and news watchers to illustrate the effects on one another both types have. The results seem to be suggesting that when news watchers pick up new information, in general they underreact. This is mainly due to the gradual diffusing of information and the assumption that they do not observe prices. When short run momentum traders enter the market, seeing a chance to profit, instead of pushing the price back towards the fundamental value, they cause an overreaction to the news. While in the short run market participants could make a profit, in the long-run they make losses due to the price exceeding the long run equilibrium price. According to Hong & Stein (1999), the inclusion of well-informed fully rational arbitrageurs does not eliminate the effects of other less informed and rational market participants. Thus meaning the overreaction continues to have an impact on the price.

Recent empirical evidence has painted a mixed picture for the overreaction/underreaction hypothesis. Spyrou *et al.* (2007) find a split between large and small capitalization stocks in the London Stock Exchange. Large capitalization stocks were consistent with the efficient market hypothesis, while medium to small capitalization stocks seem to underreact to news shocks for many days. This underreaction is unexplained by risk factors or any other known effect.

A relevant factor raised by Fakhry & Richter (2015) and Fakhry *et al.* (2016) regarding the efficient market hypothesis is that during some highly volatile periods some markets seem to be rejecting the null hypothesis of the market being too volatile to be efficient. As hinted by Kirchler (2009), the underreaction / overreaction hypothesis provides one possible explanation, which suggests that market participants' reaction leads to overvaluation or undervaluation during bulls or bears market respectively. Hence, a highly volatile period with instances of both a bear and bull market would give the impression of an efficient market.

However, contrary to Spyrou *et al.* (2007), Lobe & Rieks (2011) find significant evidence of short-term overreaction in the Frankfurt stock exchange is not limited to small capitalization stocks. The explanation seems to be in the anomalies and stock characteristics. However, transaction costs and unpredictable markets mean that market participants may not be able to exploit these effects. This means that due to the unforeseeable direction of the reaction and the existence of transaction costs prohibiting the implementation of consistent profit making strategies, they conclude the evidence seem to be suggesting no violation of the efficient market hypothesis.

A Review of the Markov Regime-Switching ARCH Models

As stated by Hamilton (1989) the basis of a number of previous researches studying the relationship between the business cycle and GNP is the assumption of the observed data following a linear stationary process. However, as a number of studies have proved the assumption of linearity and stationary in key macroeconomic datasets is weak. Hence, in an article on non-stationary time series and the business cycle, Hamilton (1989) introduced a regime-switching model based on autoregression using a discrete-state Markov process.

Conversely, it has long been acknowledged financial markets sometimes go thru alternate periods, characterized by high and low volatilities as noted by Hamilton & Susmel (1994) and Cai (1994) amongst others and highlighted by Fakhry & Richter (2015) and Fakhry *et al.* (2016). In researching monthly short-term interest rates, Hamilton (1988) concludes the possible present of regime shifts in ARCH effects could explain the estimates of the ARCH-m of Engle *et al.* (1987). In fact, a common problem in the estimation of ARCH/GARCH is spuriously high persistent of volatility across subsamples as noted by Hamilton & Susmel (1994). Diebold (1986) and Lamoureux & Lastrapes (1990) argue that structural changes in the observed dataset could be the reason for a high estimate of the ARCH/GARCH parameter, which leads to high persistent.

Thus meaning that sometimes, simple ARCH/GARCH models do not entirely explain volatility, there is a need to combine the regime-switching capabilities of the Markov switching model with conditional volatility models such as ARCH/GARCH. As noted by Cai (1994), a key factor in the use of SWARCH is the endogenisation of parameter shifts, thus allowing shifts to be determined by the observed dataset. Additionally, a key advantage is that it distinguishes between the effects enabling the analysis of their impact on the properties of the observed dataset. This led to a number of integrated models generally called SWARCH, i.e. Cai (1994), Hamilton & Susmel (1994) and Hamilton & Lin (1996).

Although the models of Cai (1994) and Hamilton & Susmel (1994) are based on SWARCH implementation, they adopt different methods of implementation. Cai (1994) models the shifts in the asymptotic long-run variance of the SWARCH process. Thus in this model the intercept of the conditional variance is allowed to change in response to the discrete shifts in the regimes. Whereas Hamilton & Susmel (1994) model the shifts in the dynamic process of the conditional variance, this means that the basis of the regime shifts are the changes in the scales of the conditional variance.

The literature on the empirical evident of the SWARCH in the sovereign debt market is not a huge one in comparison with other models. Although the Markov switching and GARCH models separately have been the focus of attention since the financial and sovereign debt crises, yet there is a drought in the empirical evident of the SWARCH model. We find a two way split in the evident with a group, such as Christiansen (2008), researching the yields and the second group such as Abdymomunov (2013) studying the returns. The significant of these two papers is that they also use different SWARCH implementations whereas Christiansen (2008) uses the Cai (1994) method; Abdymomunov (2013) uses the Hamilton & Susmel (1994) method.

In a research on the relationship between the volatility on the short rate of the US and UK and the US and Germany, Christiansen (2008) extended the Cai (1994) implementation of the SWARCH model to a bivariate model in order to estimate both volatilities, i.e. US and UK and US and Germany, simultaneously. The research used the weekly 1-month Eurodollar, Libor and Euromark[1] for the US, UK and Germany respectively; observed from January 1975 to December 2004 obtained from the Federal Reserve and Datastream. They found the inclusion of the level effect and regime switching in the model seems to be rendering the ARCH effect in the conditional volatility insignificant. In addition, the regime switching occurs in the level or constant in the ARCH model specification. Moreover, they find evident suggesting that neither a state dependant level nor volatility have an advantage over the other. The results seem to be indicating a mixed picture with each country short rate model conforming two different models with respect to the two states. However, there is a difference in the models each country conforms with respect to the states. There seem to be no evident of contagion between the US and Germany and US and UK. However, in general they did fund some evident of Granger causality. Essentially, this is suggesting that the ECB in particular can exert some influence on the Eurozone short rate volatility.

[1] After the introduction of the Euro, the rate used was Eurocurrency

In contrast, Abdymomunov (2013) extends the Hamilton & Susmel (1994) model to a multivariate SWARCH model; in a study on the impact of financial stress from abrupt and large changes in the volatility of key financial variables on the US financial. They use transformed weekly TED spreads, value-weighted NYSE returns and capital-weighted CDS from a number of banks as the financial variables obtained from various places such as Bloomberg and the FRED database of the Federal Reserve Bank of St Louis observed over the period 6 December 2000 to 29 September 2010. However, the CDS data was observed between 10 November 2004 and 29 September 2010. They find strong evident of the high volatility state in the joint variables mimicking times of financial stress such as the terrorist attacks of 11 September 2001, subprime crises and credit crunch in August 2007 and the Lehman Brothers bankruptcy in September 2008. The results seem to suggest that a possible indicator of financial stress could be the joint variables regime-switching model.

Model Specifications for Markov Switching ARCH

The main aim of this paper is to analyse the overreaction/underreaction by using the SWARCH model. The SWARCH model is basically a combination of the Markov switching model of Hamilton (1989) and the ARCH model of Engle (1982). Hamilton (1989) derived the MS(s)-AR (k) model from a combination of two or more first order autoregression models, each with a different intercept to highlight the change in the observed data at a certain time. However, as indicated by Hamilton (2008) the problem with that was priori knowledge of abrupt changes in the observed data. Hence, Hamilton (1989) introduced a multiple-state (i.e. two-state in this case) Markov chain with a system of probabilities attached to each state to model the changes in the observed data regime. The Markov Switching model as derived by Hamilton (1989), illustrated in equation 1.

$$y_t = \omega_{s_t} + a_1 y_{t-1} + \varepsilon_t \tag{1}$$
$$s_t = \begin{cases} = 1\ if\ low\ regime \\ = 2\ if\ high\ regime \end{cases}$$

As previously stated, the literature and empirical evident on the Markov switching model in the sovereign debt market in the last few years have been strong, see (Georgoutsos & Migiakis, 2012, and Pozzi & Sadaba, 2013). Given the evidence of regime switching in the volatility of sovereign debt prices over the past few years, hence a volatility-switching model would help in identifying the reaction of market participants. However, due to issues regarding the complexity, see (Cai, 1994) and (Guidolin, 2012), and the exaggerated high persistency in the volatility, see (Guidolin, 2012); we follow Christiansen (2008) and Abdymomunov (2013) in using a SWARCH model instead of a SWGRACH (i.e. Switching GARCH). In effect using the ARCH model of Engle (1982) to derive the volatility. Equation 2 uses a single lag ARCH model as proposed by Engle (1982).

$$h_t = \omega + \alpha_1 \varepsilon_{t-1}^2 where h_t = \sigma_t^2 \tag{2}$$

The simplest method to estimate the integrated heteroskedasticity and switching effects in the volatility is by the use of a SWARCH model such as Hamilton & Susmel (1994) and Cai (1994). We opt for the Cai (1994) implementation mainly due to initial tests with our observed data raising a few estimation issues with respect to the Hamilton & Susmel (1994) implementation. In combining the Markov switching model as in equation 1 with the ARCH model in equation 2, it is easy to see how Cai (1994) integrated the two models. The Cai's model is derived from the two equations, illustrated by equations 3 and 4, with the first equation being the integrated model and the second being the regime-switching probabilities. Analysing equation 3 closely reveals the beautiful simplicity in the construction of the model. Yet the model is powerful in its ability to model the regime switching in the volatility of the underlining observed dataset and complicated to estimate. The simplicity of the model is that it is a combination of the Hamilton (1989) Markov Switching model in equation 1 and ARCH model of Engle (1982) in equation 2 whereby the autoregression model in equation 1 is substituted by the conditional heteroskedasticity model as derived by equation 2. However, since Cai (1994) uses a two-lagged ARCH model, this implies that the SWARCH model follows equation 3

$$h_t = \omega_0 + \omega_1 s_t + \sum_{i=1}^{q} \alpha_i \varepsilon_{t-i}^2 \tag{3}$$

$$s_t = \begin{cases} 0\ if\ low\ volatility \\ 1\ if\ high\ volatility \end{cases}$$

$$P(s_t = i|\widetilde{\varsigma_T}) = \sum_{j=1}^{M=2} P(s_t = i, s_{t+1} = j|\widetilde{\varsigma_T}) \tag{4}$$

$$Pr_s = \frac{1}{1+Exp(\theta_{m,n})} \tag{5}$$

In the Cai (1994) model, the intercept for the low volatility regime is ω_0 and the high volatility regime calculated by multiplying ω_0 with the coefficient of the ARCH. Since the SWARCH model was originally proposed to highlight the issue of spuriously high persistence in the volatility of other models due to regime switching.

In a two-regime Markov switching model, we calculate the expected probabilities by using $\theta_{1,1}$ and $\theta_{1,2}$ logistic indices. Equation 5 illustrates the calculation; a key factor is that we substitute $\theta_{1,1}$ and $\theta_{1,2}$ into $\theta_{n,m}$ for the low and high regimes' probabilities respectively. We opt for the smoothing effect to calculate the probabilities. This gives a more accurate figure of each probability, but requires extensive computing, due to the complex estimation method involving the entire history of filtered and predicted probabilities, see Hamilton (1994).

Data Description

As illustrated by Table 1, we use the daily 10-year sovereign debt, maturing in 20120F[2], end of day bid prices for Germany, Greece, Italy, Portugal, Spain and US obtained from Bloomberg. Importantly, the reference numbers are ISIN for all the markets, except the US which uses CRSPID. In order to capture the price volatility during the sovereign debt crisis without the maturity effect, we extend our data to obtain a second group of sovereign bonds for the above-mentioned countries with the exception of Greece maturing in 2017 as illustrated in

Table **2**. We follow the norm by defining our week as Monday to Friday. In order to make the observed data uniformed across all six observed datasets, we substitute all missing observations with the last known price.

Table 1. *The 10-Year Sovereign Debt Prices Data with maturity in 2012*

	Reference Number	*Download Date*	*Issue Date*	*Maturity Date*
German	DE0001135192	16/07/2012	02/01/2002	31/12/2011
Greece	GR0124018525	17/12/2012	17/01/2002	18/05/2012
Italy	IT0003190912	16/07/2012	01/08/2001	01/02/2012
Portugal	PTOTEKOE0003	16/07/2012	12/06/2002	15/06/2012
Spain	ES0000012791	17/12/2012	14/05/2002	30/07/2012
US	9128277L0	16/07/2012	15/02/2002	15/02/2012

[2] The exception is the German which matures at the end of 2011

Mainly due to the last issue date, that of Portugal, and first maturity date, that of Germany, our observed sample is from 1st July 2002 to 30th December 2011. Thus meaning our sample has a uniformed total of 2,480 daily observations for each sovereign debt market.

Table 2.*The 10-Year Sovereign Debt Prices Data with maturity in 2017*

	Reference Number	*Download Date*	*Issue Date*	*Maturity Date*
German	DE0001135317	08/04/2013	17/11/2006	04/01/2017
Italy	IT0004164775	08/04/2013	01/08/2006	01/02/2017
Portugal	PTOTELOE001 0	08/04/2013	18/06/2007	16/10/2017
Spain	ES00000120J8	08/04/2013	23/01/2007	31/01/2017
US	912828GH7	08/04/2013	15/02/2007	15/02/2017

In our second observed sample, we follow the same concept as before by using the Portuguese issue date to set the start. This means our observed sample is from 1st July 2007 to 31st March 2013, a total of 1,500 daily observations for each sovereign debt market.

Empirical Evidence

We use the Cai (1994) variant of the SWARCH model as indicated earlier to analyse the regime-switching behaviour of volatility in the sovereign debt market. We derive a single lagged two states SWARCH to model the switching conditional variance of the first order-differentiated price.

In estimating our SWARCH model, we use the maximum likelihood with normal distribution. With the exception of the US and German 2017 datasets, we use the BHHH method. However, due to errors in the estimations of these two datasets, we opted to use the BFGS method. Due to errors with the estimations, we used various sample periods.

Table 3. *SWARCH Statistics of the 2012 Bond*

	US	*Germany*	*Greece*	*Italy*	*Portugal*	*Spain*
Mean Eq. M	-1.58E-2 (1.06E-3)	-1.33E-2 (1.60E-3)	4.93E-3 (4.82E-3)	-9.22E-3 (2.19E-3)	2.38E-3 (4.22E-3)	-7.25E-3 (3.50E-3)
Variance Eq. ω_0	5.01E-4 (4.15E-5)	8.29E-4 (1.31E-4)	3.74E-2 (1.96E-3)	4.21E-3 (3.24E-4)	3.64E-2 (1.79E-3)	9.20E-3 (8.39E-4)
$\omega_{s=1}$	0.293810 (0.02157)	0.253356 (0.0355)	0.335285 (0.04391)	0.158109 (0.03212)	0.033347 (0.02050)	0.085378 (0.02609)
$\omega_{s=2}$	0.314870 (0.029868)	0.092030 (0.02164)	0.105865 (0.0227)	0.092066 (0.02193)	-0.002624 (0.00115)	0.113403 (0.02237)
α	166.03853 (13.7276)	48.809924 (7.38853)	43.495632 (9.50358)	11.191042 (0.85112)	10.619878 (1.04933)	6.523605 (0.55092)
$\theta_{(1.1)}$	7.018339 (1.06231)	4.815815 (0.67957)	4.380112 (0.27218)	4.840678 (0.45375)	3.846200 (0.27491)	4.530508 (0.42917)
$\theta_{(1.2)}$	-7.752714 (0.59254)	-5.930005 (0.60767)	-1.846393 (0.31131)	-5.598055 (0.45617)	-2.164589 (0.31478)	-5.352082 (0.44011)
$Pr_{s=1}$	8.95E-4	8.04E-3	1.24E-2	7.84E-3	2.09E-2	1.07E-2
$Pr_{s=2}$	0.99957	0.99735	0.8637	0.99631	0.89702	0.99528
Log Likelihood	187.0060	1097.174	-530.0750	837.6236	-91.3807	362.2630

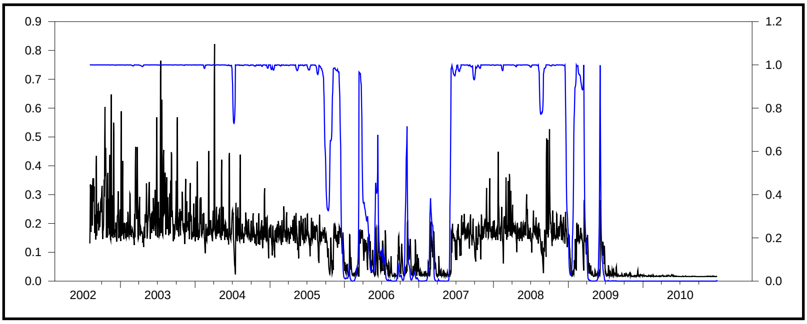

Figure 1. *US 2012 High Volatility Regime*

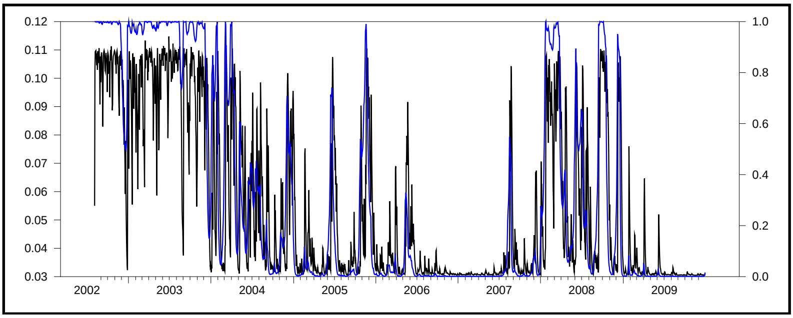

Figure 2: *German 2012 High Volatility Regime*

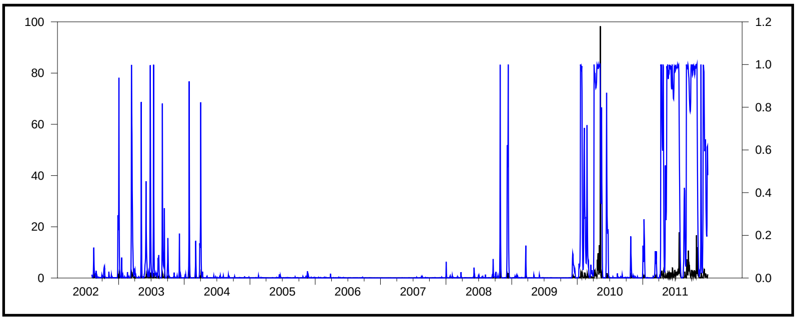

Figure 3: *Greek 2012 High Volatility Regime*

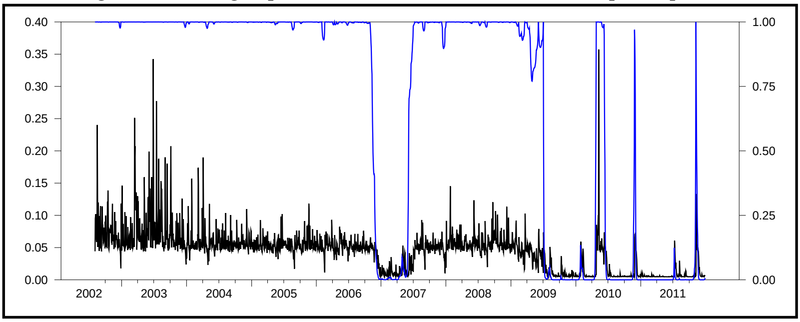

Figure 4: *Italian 2012 High Volatility Regime*

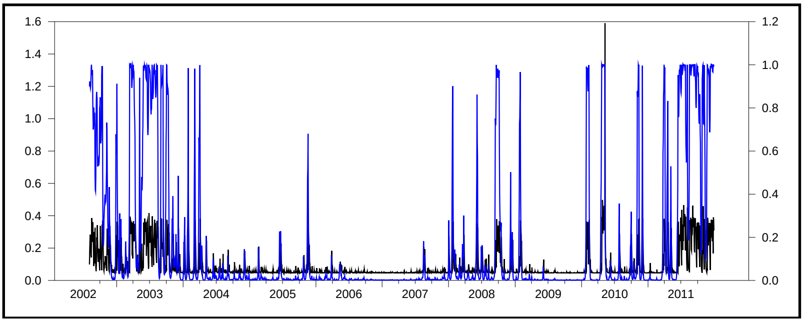

Figure 5: *Portuguese 2012 High Volatility Regime*

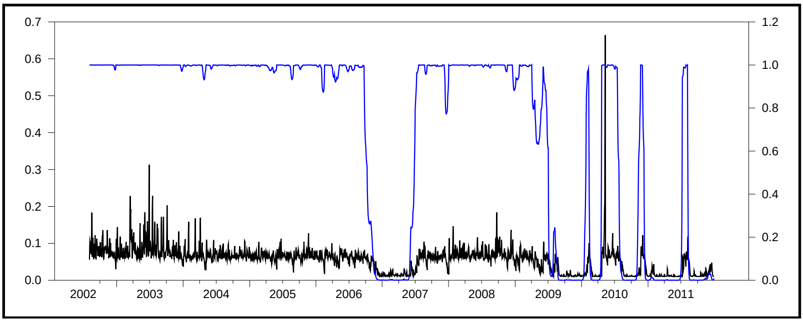

Figure 6: *Spanish 2012 High Volatility Regime*

In essence, the 2012 bonds were associated with a period of changing market environment in the global financial market. Of course the later stages of the period were associated with the financial and sovereign debt crises, yet it was also governed by a number of events which changed the market environment during the earlier stages such as the asset price bubble and accountancy issues leading to the bankruptcy of Enron and WorldCom. However, two events, which had an influential impact during the early stages, were the introduction of the euro and the terrorist attacks of 11 September 2001 leading to a number of wars. Although these two events occurred before the observed period, yet the persistency in their aftermath had a big impact on the behaviour of market participant.

The evidence from figures 1 to 6 certainly points towards the existence of a regime-switching behaviour influencing the pattern of price volatility in the sovereign debt market. While the figures illustrate the extent to which the sovereign debt market in general is highly volatile, further illustrated by analysing the probabilities of the high volatility regime in table 3, in essence regime 2. Surprisingly for our observed markets, this is highly significant with a minimum probability of 0.8637 as observed by the Greek market, backed by the probability for the low volatility regime, which is regime 1, with a maximum probability of 0.0209 for the Portuguese market. This would suggest it is more likely that the next regime will be highly volatile. With the exception of the Greek and Portuguese markets, the probabilities are in the high 0.90s, which are hinting at the other observed markets being more volatile. Notably the Greek and Portuguese markets also point to a significant probability of a high volatility regime.

In general, the ARCH intercepts seem to be hinting at a three way split in the markets. This is consistent with previous observation of the behaviour of volatility in the sovereign debt market, see Fakhry & Richter (2015) and Fakhry *et al.* (2016). The ARCH intercepts in both regimes for the Italian and Spanish markets seem to be hinting at very low levels of volatility, understandable as the high volatility did not impact the two markets until the later stages as illustrated by figures 4 and 6. Both these figures also illustrate that the highly volatile period of the early 2000s did not really influence the volatility levels. Arguably, the financial crisis did not affect the Spanish market until later on and the Italian market remained unaffected.

The US and German markets seem to be portraying a more volatile market than the other observed markets. However, as illustrated by figures 1 and 2, at the highest level their volatilities are below the Greek and Portuguese markets. A counter argument is during some spells the level of volatility for the German and especially the US markets seem to be higher than the Greek and Portuguese markets. A possible explanation is the quality and liquidity factors of the US and German markets making them the benchmark markets for both the dollar and euro currencies. This makes them prime markets for flights to safety during crises or extreme events i.e. Knightian uncertainty. Another influencing factor with respect to both markets is the requirement of the Basel II regulations to hold sovereign debt on their balance sheets as capital. Hence, many of these organizations choose to hold either US or German sovereign debt depending on their "home" currency.

The Greek and to a lesser extent Portuguese markets were in the "eye of the hurricane" during the sovereign debt crisis, hence the high levels of volatility, as illustrated by figures 3 and 5, which had an impact on the regime 2 ARCH intercepts. However, as the figures also illustrates there are long periods of low volatility in both the Greek and Portuguese markets. An influencing factor is that both these markets are not liquid and more importantly are not large markets. Hence, as illustrated by the figures, during "normal" market environment these markets do not have a high number of transactions, which gives the appearance of stable markets.

In essence, the 2017 bonds are associated with a highly volatile period in the global financial market mainly due to the financial and ensuing sovereign debt crises. Although, this in itself is interesting, mainly due to the differing impact on the observed markets of each crisis; however, as hinted previously, another influencing factor is the different impact from the on the run and maturity effects on the financial and sovereign debt crises respectively. The final factor is the extended observed period; therefore, allowing us to analyse the full impact of the sovereign debt crisis. These factors may have had an effect on the SWARCH model.

Table 4. *SWARCH Statistics of the 2017 Bond*

	US	*Germany*	*Italy*	*Portugal*	*Spain*
Mean Eq.	-7.64E-4	1.18E-2	5.38E-3	-1.46E-2	-1.68E-3
μ	(6.83E-3)	(7.39E-3)	(8.20E-3)	(1.15E-2)	(8.93E-3)
Variance Eq.	1.95E-2	2.88E-2	6.68E-2	1.34E-1	1.04E-1
ω_0	(2.02E-3)	(7.77E-3)	(3.95E-3)	(9.01E-3)	(4.93E-3)
	0.135506	0.0897424	0.0063287	0.014309	0.076919
$\omega_{s=1}$	(3.18E-2)	(4.07E-2)	(1.69E-2)	(3.30E-2)	(3.42E-2)
	0.071336	-0.0269799	0.0710576	0.096304	-0.006101
$\omega_{s=2}$	(3.46E-2)	(4.62E-3)	(3.13E-2)	(3.28E-2)	(5.47E-4)
	12.987887	4.5921499	10.1028920	16.841144	7.764033
α	(1.250402)	(0.839103)	(1.137037)	(2.236902)	(0.977439)
	6.571102	3.2786740	3.7757628	3.331685	4.512419
$\theta_{(1.1)}$	(1.492712)	(0.393502)	(0.274308)	(0.257237)	(0.402756)
	-7.203025	-4.0878472	-2.2659541	-1.738651	-2.670022
$\theta_{(1.2)}$	(1.235778)	(0.570678)	(0.283508)	(0.351140)	(0.382444)
$Pr_{s=1}$	1.40E-3	3.63E-2	2.24E-2	3.45E-2	1.09E-2
$Pr_{s=2}$	0.99926	0.98350	0.90602	0.85052	0.93523
Log Likelihood	-761.8270	-352.5236	-590.8467	-1242.7689	-749.8844

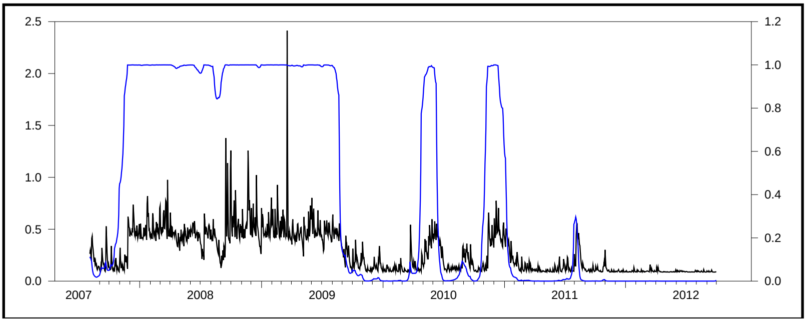

Figure 7: *US 2017 High Volatility Regime*

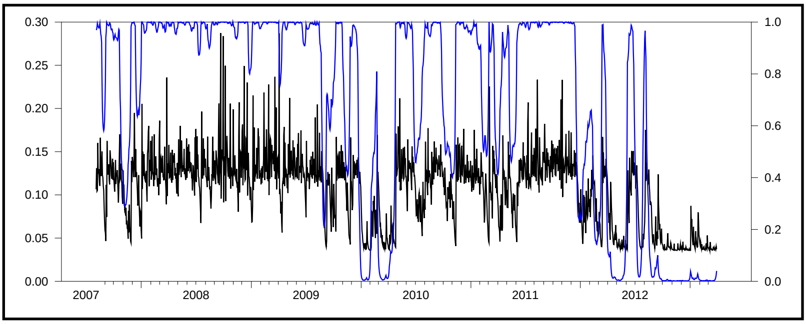

Figure 8: *German 2017 High Volatility Regime*

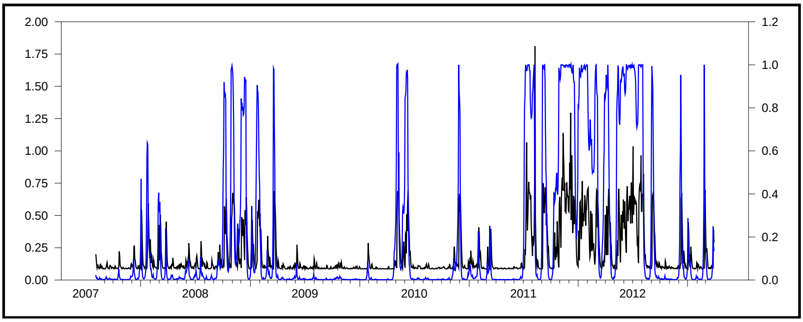

Figure 9: *Italian 2017 High Volatility Regime*

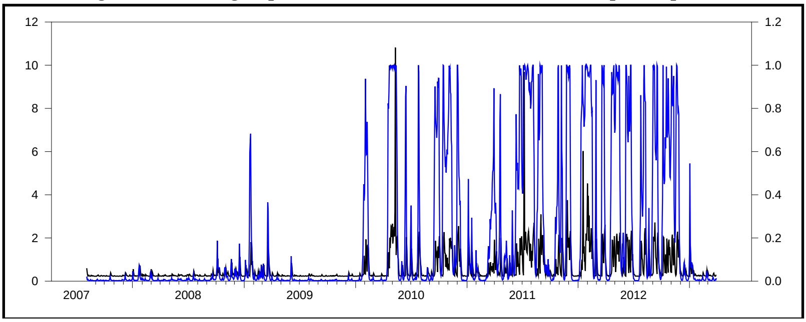

Figure 10: *Portuguese 2017 High Volatility Regime*

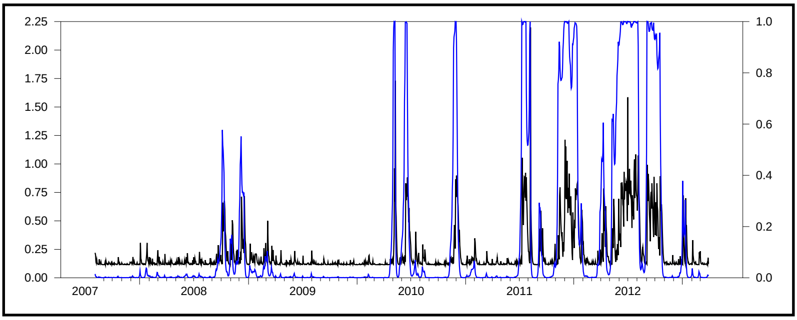

Figure 11: *Spanish 2017 High Volatility Regime*

The evidence from table 4 is pointing at a mixed picture with respect to the probabilities. The high probability of regime 2 suggests that there is a significant probability of a highly volatile regime throughout our observed markets. With the exception of the Portuguese market, the observed markets are hinting at a significant probability of above 0.9 that the next regime is highly volatile. With the US and German markets approaching 1.0, this seem to be indicating that the US and German markets were highly volatile throughout the observed period, although the probabilities of both the Italian and Spanish markets were also significantly high.

Like the probabilities, the ARCH intercept for regimes 1 and 2, points at a rather mixed picture in terms of the level of volatility in the observed markets. As illustrated by figures 7 to 11, it would seem that the German market had the lowest level of volatility in both regimes. An influencing factor is that both crises did not really affect the German economy or financial market, despite the downgrading of the German sovereign debt ratings. However, the evidence from figure 8 seems to suggest that the market was highly volatile and backed by the high probability of regime 2 as hinted earlier. A possible explanation is the status of the German market as the benchmark market for the Eurozone; hence, the persistency of the high volatility regime is the result of flights to safety during both crises. Similarly, the persistency of the high volatility regime in the US market during the early stages was the result of a flight from financial assets to the US market during the financial crisis. Since the financial crisis had its origin in the US; hence, these flights to safety as illustrated by figure 7 significantly affected the US market. However, the timings of the two hikes in volatility during the sovereign debt crisis period seem to be hinting at the Eurozone sovereign debt crisis, hence a plausible explanation is that the US market was at the centre of a flight from the euro to the US dollar. It must be remembered that due to problems with the estimation of the SWARCH model, we had to limit our observed dataset to 1st October 2012, which meant the full impact of the US fiscal cliff and debt-ceiling crises on the US market was not captured.

To a certain extent figures 9 to 11 seem to be hinting at the limited impact of the financial crisis on the IPS markets. Although there is some evidence of high volatility regimes during the financial crisis period, yet this evidence seems to be telling. Certainly, the evidence seems to be pointing at jumps rather than changes in the volatility regime effecting these markets during the financial crisis, especially around the period of the Lehman Brothers bankruptcy. This seems to be hinting at a period of reactive behaviour by the market participants to events during the financial crisis period.

However, during the sovereign debt crisis, the regime changes became increasingly persistence and frequent. An interesting factor is the lag between the Greek deficit revision and the reaction of the market participants leading to contagion in the IPS markets.

Conclusion

In this paper, we used the SWARCH model volatility regime switching proposed by Cai (1994) to analyse the reaction of the market participants in a fast changing and highly volatile environment. In order to overcome the "on the run" and maturity effects, we used two group of government bonds: the 2012 bonds and 2017 bonds. We used the prices of the GIPS plus US and German markets. The aim was to analyse the changing reaction of the market participants during the pre-crisis period and the financial and sovereign debt crises.

In summarising, the SWARCH model seems to point to a regime-switching behaviour in the price volatility of the sovereign debt market. In general, the high volatility regime in both the 2012 and 2017 bonds governed the SWARCH model. The SWARCH model also seems to highlight an interesting factor in the 2012 bonds, the observed markets seem to be generally divided into three groups depending on the pattern of the volatility and regimes: the US/German, Greek/Portuguese and Italian/Spanish markets. Another factor observed in the patterns of volatility in the 2017 bonds is that the IPS markets do follow a similar pattern of volatility while the US and German markets seem to be dictated by individual patterns of volatility. A relevant factor in our research is that the SWARCH model seems to be identifying the changing environment for each of the observed markets. Since each of the markets was effected by a number of different factors.

In concluding, the evidence does hint at the changing environment effecting the market participants' reactions. Thus indicating an overreaction/underreaction during both crises in the sovereign debt market. However, there was evidence of underreaction during the pre-crisis asset bubble and to a certain extent the financial crisis, since the macroeconomic indicators were indicating the worsening underlying economic condition in the observed markets.

A big issue is that market participants also react to policy makers; the problem is that during both crises the policy makers were also reacting to events. At the heart of both crises there was confusions bought on by mixed political communications. These two issues illustrate a genuine lack of ideas and agreement by the policy makers leading to an overreaction. Another issue is both crises were highlighted by incomplete or asymmetrical information. The sad thing was that the spillover effect that followed the initial crises was a consequent of the overreaction to the indecision of the policy makers.

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4 Did Brexit change the behaviour of the UK's financial markets?

Introduction

In an unprecedented move, on 23 June 2016, the UK voted to leave the European Union by a margin of 51.89% to 48.11%. The result signalled the start of the so-called Brexit process whereby the negotiations over the withdrawal of the UK from the European Union could start. This was initiated by the UK's government on 29 March 2017 when they invoked Article 500F0F[4] of the 2007 Lisbon Treaty1F1F[5] which set out the guidelines and conditions of a member state withdrawal from the European Union.

Conversely, according to Hobolt (2016), in the wake of the Brexit vote the financial markets reacted quickly with the pound plunging to a 31-year low against the dollar and the global stock markets losing over two trillion dollars. This would hint at the overreaction hypothesis being in play in

[4]See [Retrieved from] for details of Article 50 of the 2007 Lisbon Treaty

[5] See [Retrieved from] for details of the 2007 Lisbon Treaty.

the financial market in the aftermath of the Brexit vote. However, in recent years the global political and economic environment have changed, mainly due to the global financial crisis and ensuing economic downturn. The resulting Brexit vote was partly the product of this changed in the environment. In essence, this may have had an impact on the market participants making them highly reactive to any news that brings added uncertainty.

According to a number of articles including Dorling (2016), Hobolt (2016) and Inglehart & Norris (2016); the signs were there from the start. Inglehart & Norris (2016) state that two theories come into play as for the rise of populist policies: the economic insecurity perspective and culture backlash thesis. At the heart of both these theories are common grievances such as immigration, integration and globalisation, as hinted by Hobolt (2016) and Dorling (2016). A reflection of the Brexit vote would illustrate this, Dorling (2016) argues that the 59% of the middle classes voted to leave the EU as opposed to 24% from the poorer classes.

As stated by Hobolt (2016), in truth the Brexit vote highlight a divide not just among the British but across Europe which resulted in the results of recent general elections in Europe such as the French and German. It is worth remembering that financial markets react to political instability which goes to the heart of the increasingly reactive nature of the UK's financial markets in the aftermath of Brexit. The results of the Brexit vote highlighted major political issues and divisions in the UK, this instability was confounded by the following general election which produced a hang parliament at a time when the UK needs a strong government. As highlighted by Taylor (2009) and Carmassi & Micossi (2009), often financial markets tend to react to uncertainty and miscommunication by governments. In the run-up to the referendum and, to a certain extent, aftermath of the Brexit vote; the conflicting statements and confusions not only by members of the British government but also by members of the EU, as hinted by Hobolt (2016), led to a highly reactive financial market.

Was the Brexit result a shock to the market, in a way it should not have been as Hobolt (2016), Dorling (2016) and Inglehart & Norris (2016) identified, the indicators were there. However, even the politicians advocating Brexit were not sure of the results, as stated by Hobolt (2016), and many in the financial market as did many political commentators thought that the threat to economic stability and certainty would defer enough from voting for Brexit.

With this change in the environment across different aspects in mind, we analyse the UK's financial markets to determine the change in the market's environment in the aftermath of the Brexit vote in the long and short runs. We use the daily prices on four indices representing the Equity. FX, commodity and sovereign debt markets. Using an asymmetrical C-GARCH-m variance bound test based on the test used by Fakhry & Richter (2018) to analyse the feedback effect in addition.

A major contributory factor to this paper is as hinted in Fakhry (2016), since the variance bound test indicates that if a market is inefficient then it is deemed to be too volatile to be efficient. Simply put, this means that for a market to be efficient the pre-condition is a measurable stability status. Hence in short, the variance bound test is a test of this stability pre-condition. Therefore, we differ from many in the past by using the variance bound test to analyse the stablemarketpre-condition hypothesis and hence the efficiency of the market, whereas most have used the variance bound test to analyse the efficiency of the market, examples are Fakhry & Richter (2015, 2016a, 2016b, 2018) and Fakhry *et al.*, (2016, 2017). Thus the key to our analysis is using the variance bound test to analyse the stability of the markets which is of greater importance than the efficiency.

However, the stability status of any market during any observational period would naturally indicate the efficiency of the market.

There are a number of further contributions, we make to the literature on financial econometrics and the Brexit debate. The first and most important of which is that this paper is unique in that it is the only, thus far, to analyse the impact from Brexit on the reaction of the market participants in the UK's financial markets. For this extent, we extend the variance bound test first proposed by Fakhry & Richter (2018) to also analyse the feedback effect, thus using an asymmetrical C-GARCH-m model to analyse the different behaviour of price volatility and the impact of Brexit on the stability of the market. Furthermore, the paper also contributes in using four major UK markets to determine the true extent of the impact from Brexit on the UK's financial market, following from Fakhry & Richter (2018). Finally, the paper is thus far the only paper to carry out a timeline analysis on the impact of Brexit on the UK's financial market.

We found evidence suggesting that there were some changes in the general behaviour of the financial markets in the aftermath of the Brexit vote, especially in the short run. However, as we suspected, the evidence did point to a limited change in the behavioural factors of the price volatility which suggests that the markets have not fully recovered from the recent financial crises including the sovereign debt crises. Yet our analysis seems to hint at a hike in volatility across all four financial markets in the immediate aftermath of the Brexit vote.

We conclude while the Brexit vote did impact the UK's financial market in the short run and slightly in the long run. However, a big question is whether this was a continuation of the market participants reaction to uncertainty during the recent financial crises or a new period of uncertainty bought about by Brexit. Certainly, there is some evidence pointing to the existence of the continuation factor. The issues of miscommunication and confusion from the government illustrate that policy makers have not learnt the lessons of the recent financial crises. Based on our findings, we advise the policy makers to make clear and decisive statements. We also recommend an agreement among all the policy makers to put forward a unified voice and plan. It is essential not to repeat the same mistakes made during the financial crises and early parts of the Brexit process.

The rest of this paper is divided into six sections; the first two sections are reviews into the impact of Brexit on the economy and financial markets. The third section is the methodology which precedes the data description. We then provide our empirical evidence of the impact of Brexit on the financial market. Concluding the paper with the conclusion.

A literature review of the impact of Brexit on the UK's economy

Although this paper is essentially about the behaviour of financial markets during the uncertainty of Brexit. It is important to observe that the real impact of Brexit on the UK's financial markets comes not from the UK leaving the EU but from the effect of Brexit on the UK's economy. As we will see, the UK's economy is predicted to contract by anything up to 5% in the aftermath of Brexit in accordance with reliable sources. Of course, these predicted statistics are based on a number of scenarios made before the UK's government decision on which policy to pursue, we now know that the UK is heading to an EU/UK free trade Agreement or failing that a hard Brexit on the 31st March 2019. So, the economy is likely to be the major source of price volatility and uncertainty in the short run, this is confirmed by the UK's Economic Policy Uncertainty[6]I as illustrated by

[6]See [Retrieved from] for details on the EPU

Figure 1, especially in the aftermath of the actual Brexit. Additionally, much of the uncertainty in the financial market comes from the confusions and miscommunication about the economy. Hence a review of the literature on the economy is vital in understanding this main source of uncertainty and volatility in the aftermath of the referendum.

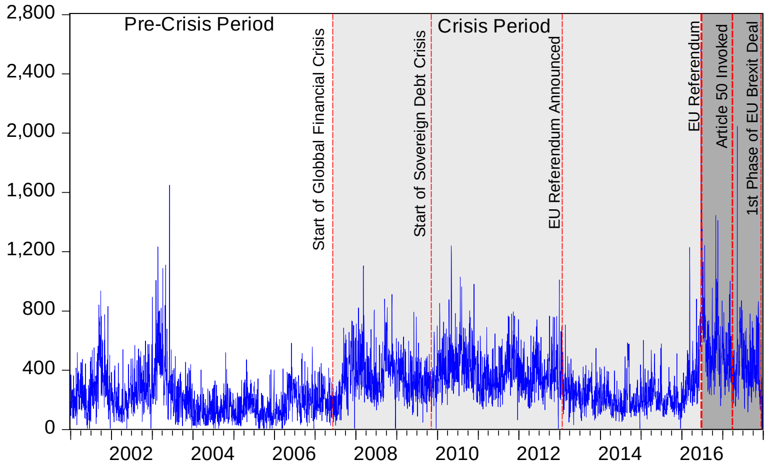

Figure 1. *UK Economic Policy Uncertainty Index*

A review of the options would suggest that there were only three realistic options available for the UK and EU. As highlighted by a number of articles such as Erken *et al.*, (2017) and Sampson (2017), the options included: Soft Brexit, Hard Brexit and an EU/UK free trade agreement. As hinted by Brakman *et al.*, (2017), the problem is that negotiations between the UK and EU on a new trade deal are likely to be confrontational and difficult, mainly due to politics on both sides. And as stated by Niederjohn *et al.* (2017, p.86), a key issue is that members of the EU:

> "seem determined to make an example of Britain for fear that if the UK negotiates too good a deal, other nations will vote to leave too"

This was illustrated on 6th December 2016 by a speech from the EU's chief negotiator, Michel Barnier, in a press conference on Brexit in which he said:

"Cherry picking is not an option"

According to Erken (2017), the soft Brexit option would mean that the UK retains its membership in the single market under the European Economic Area or EEA agreement but leave the Custom Union. As Sampson (2017) states, this would mean the UK would continue to get free market access for goods, services and capital across the EU. However as illustrated by Sampson (2017), this would also mean having to sign to a free movement of labour, which was one of the main reason for the Brexit vote according to Hobolt (2016) and Dorling (2016) and contributing to the EU budget. Conversely, the EEA also entails the adoption of all EU legislation regarding the single market as hinted by Sampson (2017). And the UK has already signalled that it will not pursue this avenue as confirmed by the secretary for the Department of Exiting the EU, David Davis MP in a speech to the House of Commons on 7th September 2017:

"The UK will no longer participate in the EEA agreement once it leaves the European Union"

Adopting the hard Brexit option would mean a complete and total divorce between the EU and UK without any trade agreement, as hinted by Erken *et al.*, (2017). According to Sampson (2017) and Erken *et al.*, (2017), this would result in a World Trade Organisation's trade agreement between the EU and UK, along the lines of the agreement which both the US and China have withthe EU. Under the agreement goods would be subject to most favoured-nation tariffs. As indicated by Sampson (2017), the average EU tariff as of 2015 was 4.4%. However, as hinted by Sampson (2017), there has not been a similar agreement for the trade in servicesincluding the financial sector. Conversely, as hinted by Chang (2017), the WTO trade agreement forms the basis of the argument that the UK could do better outside the EU put forwards by the EFT3F3F[7].

The third option is to negotiate a new trade agreement with the EU as hinted by Erken *et al*., (2017) and Sampson (2017). As illustrated by Sampson (2017), the agreement could take a number of shapes. However, as illustrated by Sampson (2017), in order to maintain the advantage of being part of the single market; most EU trade deals, such as the EU-Canada agreement, do much less to harmonize economic regulations and do not include free or reduced tariff access for service providers. Consequently, any free trade agreement would come with a higher trade cost to the UK. And as Sampson (2017) and Kierzenkowski *et al*., (2016) hint negotiations for a free trade agreement are unlikely to be concluded before March 2019, the EU/Canada negotiations took 8 years. This point is also alluded to by Busch & Matthes (2016) who states that any negotiation on a new trade deal with the EU or any other country could take a long period of time. Conversely, in an interview with Belgian newspaper, De Tijd on 24th October 2017, Michel Barnier warned that a trade deal between the EU and U.K. would take three years to negotiate and may unravel, stating:

> "Three years if we start talking in December. It comes with risks too, because all parliaments have to give approval [to a new deal]."

However, the negotiations for a new trade agreement between the EU and UK could follow existing templates with other countries. As illustrated by Sampson (2017), the UK could follow the Turkish template and join the custom union, this would alone would not solve the key issues of inner-border barriers and services trade. It would also have the disadvantage of preventing the UK from negotiating

[7] Economists for Free Trade formerly known as Economists for Brexit

with non- EU nations. Another option would be to follow the Swiss template with tighter integration, effectively meaning that Switzerland is in a single market in terms of goods. However, this again means that the UK will have to adopt EU economic legislations, freelabour movement and contribute to the EU budget. Despite these concessions, EU/Switzerlandagreement didn't include services; in essence putting a block on the Swiss banking industry within the EU.

The importance of this last statement is underlined by analysing the dependency of the UK's economy on the financial services industry. According to Armour (2017), the financial services sector generates between 7 to 12 percent of GDP, it also accounts for 11% of total tax receipt and employs 7-12 percent of the total workforce. Additionally, the financial service sector is responsible for the biggest trade surplus of any sector as highlighted by Armour (2017). The issue, as illustrated by Armour (2017), isthat about 24% of the total revenue is dependent on intra-EU operations. Hence a free trade agreement without including services or at the very least financial services would be detrimental to the UK's economy. However, in a speech by Michel Barnier in a press conference on Brexit negotiations dated 18th December 2017, he said:

> "There is no place (for financial services). There is not a single trade agreement that is open to financial services"

Nevertheless, it is dangerous to understate the importance of the UK's financial services to the EU as illustrated by Armour (2017). Furthermore, a disagreement on whether to include financial services in the final deal has the potential to cause high levels of uncertainty and volatility in the EU's economy as Belke *et al.*, (2016) hints, hitting the GIPS countries the most.

The literature on the estimated impact of Brexit on the economy of the UK varies with each option and depends on the initial view point of the author, a point illustrated by Busch & Matthes (2016) and Chang (2017). As Busch & Matthes (2016) argue a large amount of research have been done on the economic impact of Brexit on the UK, the results range from significant benefits to marked losses. With the more reliable researches predicting a loss of between 1 and 5 percent of GDP. Brakman *et al.,* (2017) also alludes to this variety of results,the rebalancing of trade will more likely reduce trade and economic welfare, estimates range from 1.5% to 7.0% of GDP depending on the type of Brexit. Chang (2017) states there are a number of estimates of the impact of Brexit on long-term economic growth, ranging from pessimistic to optimistic:

- the LSE and HM Treasury predict a decrease in growth of 7%
- OCED with a negative growth rate of 5%
- CBI/PwC, NIESR and Oxford Economics hint at a 3% decrease.
- The only optimistic view was from the EFT with an increase in growth rate of 4%. It must be stated that this optimistic view relies on the full uniliteral adoption of the WTO free trade agreement which many critics have slated as "*far removed from reality*", Chang (2017, p. 13).

Dhingra *et al.,* (2016) states that depending on the type of Brexit, the short run loses would be between 1.3% and 2.6% on economic growth. If the UK decides to unilaterally adopt the FTA, economic growth would be reduced by 1% to 2.3%. In the long run the cumulative effect on economic growth from Brexit could be around -6.3% to -9.5%.

Erken *et al.,* (2017) show that in all three options the UK will experience a recession immediately after Brexit. The different is that in the long run the decrease would vary in size with a free trade agreement the reduction would be 2.5%, soft Brexit would produce a fall of 10% and hard Brexit would decrease the growth by 18%.

As put by Chang (2017), the reality of the situation is unless the UK can somehow maintain full access to the EU market without a high price, Brexit could have a sustained negative impact on the economy. However, as suggested by Gudgin *et al.*, (2017) while the losses in the UK economic growth are inevitable, the size of these losses could be offset by three factors: a lower sterling FX rate, fiscal stimulus policies and monetary expansionary policies.

A further consequence of Brexit, as Emerson *et al.*, (2017) hints, is that many companies, especially those in the services industry, are considering redirecting their investment from the UK to the EU to benefit from being inside the EU. Hence, Emerson *et al.*, (2017) points to studies by HM Treasury and the OCED hinting that when accounting for Foreign Direct Investment, the economic growth loss could be even greater at 7.5% in the long run that is an average of 0.75% annually.

A Literature review on the reactions of market participants to Brexit

The financial markets are highly reactive to any event inducing uncertainty. The key here is the interpretation of events during the Brexit negotiations and the economic statistics. As elegantly put by Bernard Baruch (Lee *et al.*, 2002, p.2277),

> "What is important in market fluctuations are not the events themselves but the human reaction to those events."

On 20 February 2016, the UK's prime minister announced the date of the EU referendum, the following Monday the pound fell by approximately 2% and 1.5% against the dollar and euro respectively. As Haan *et al.*, (2016) points some have suggested that the hike in volatility and decrease in the pound value were to be expected in the financial market during the period of the EU referendum and that the financial markets would get increasingly volatile as the date get closer and thereafter. Others put the run on the British pound as just an overreaction and pointed out that financial markets are by their nature volatile. In this part of the literature review, we will review the theoretical and practical literature on the reaction of the market participants during the early stages of the Brexit process including the EU referendum and the aftermath. We will also review the limited empirical evidence of the reaction. Finally, we will review the academics views of Brexit.

As stated by Carmassi & Micossi (2010), it is not uncommon for financial market to grossly overreact; an example is the Eurozone sovereign debt crisis which started with Greece. The funny thing is Greece's public debt is a tiny proportion of the Eurozone total debt and banks' capital, yet the crisis grew into a full blown Eurozone sovereign debt crisis. As hinted by Collignon *et al.,* (2013), conflicting views on the solution to the sovereign debt crisis between key members and an initial lack of will to take action sent contradicting signals to market participants. This was further enhanced by each member state putting its own interest ahead of the EU's. And as stated by Carmassi & Micossi (2010), at the heart of the Eurozone's sovereign debt crisis was the big issue of political miscommunication and confusions. In fact, as highlighted by Collignon *et al.,* (2013), the issue of political miscommunication and confusion was the leading reason for market participants lack of willingness to hold the Greek sovereign debt and more importantly price the asset accordingly, this led to a hike in the required interest rates or yields. Mainly due to the perceived risk of default. In essence it was this political miscommunication and confusion which was at the heart of the contagion effect and the duration of the crisis.

Given as illustrated previously by the comments of those involved in the Brexit process, be it during the referendum or the negotiations, once again political miscommunications and confusions seem to be at the heart of the uncertainty within the financial markets. As highlighted by Gade *et al.*, (2013), political miscommunication does tend to have a negative asymmetrical effect on financial markets, thus meaning that negative communication has an increased impact on financial markets than positive communication. And as hinted by Gade *et al.*, (2013) the impact of the political communication on the financial markets is highly susceptible to the attributed person/organisation, this means the financial markets would react more heavily with the levels of importance of the originating person/organisation is to the event. In short, there seem to be a positive correlation between the importance of the originating person/organisation and the impact on the markets. Certainly, the evident seem to suggest there is a link between the political communication and the volatility of the financial markets during Brexit.

A further complication of the financial market reaction to the Brexit process is the area of policy uncertainty as suggested by Belke *et al.*, (2016). As stated by Smales (2017), a key factor found in previous studies of the impact of political uncertainty on financial markets is a change in the political orientation or a sudden policy change can dramatically increase financial market uncertainty. And as illustrated by Smales (2017), past empirical evidence has found that national elections have a positive relationship with uncertainty in the financial market. This relationship has an increasingly positive correlation as the election approaches. The magnitude of the impact on the financial market is determined partly by the margin of victory andchanges in the political orientation. Furthermore, financial markets are increasingly volatile when the result is uncertain. In addition, the financial markets' reaction is dependent on whether the current status quo is continued.

Conversely, the evidence seems to suggest the industries dependant on trade are especially sensitive to political events.

Smales (2017) finds that during the EU referendum there was a significantly positive relationship between market and political uncertainty. Put simply, as political uncertainty rises or fall an equivalence rise or fall in uncertainty is registered in the financial markets. the magnitude of this relationship was heightened in the aftermath of the announcement of the referendum. As suggested earlier, they found that the influence of political uncertainty from the EU referendum increase as the polling day approaches. Moreover, the result seems to be consistent with past findings that market uncertainty significantly increases with political uncertainty when opinion polls indicate a very close outcome.

Belke *et al.,* (2016) also argue that a key affect during the Brexit campaign was the impact of the poll updates on the financial markets. Gropp (2016) states evidence from the polls before the Brexit referendum seem to suggest a negative impact on the banks stocks and FX markets of the EU and UK. when the polls suggest a Brexit. This is further highlighted by Danielsson *et al.,* (2016), who states that the markets are reacting to a substantial shock indicating weaknesses for sterling and global asset markets, especially banks. Thus, hinting at a negative impact on banks stocks and FX markets in the event of a Brexit vote. However, as pointed by Gropp (2016), a key factor is the differentiation of the UK leaving the EU and the impact on the Euro in the FX markets. A key factor, as Belke *et al.,* (2016) hints, is that policy uncertainty typically tends to lead to option value effect, a "*wait and see attitude*" by market participants.

Using a VAR variance decomposition-based model proposed by Diebold & Yilmaz (2009) with the daily UK's economic policy uncertainty index and CBOEVIX index observed from 01/01/2001 to 23/09/2015. Belke *et al.*, (2016) results seem to confirm that policy uncertainty about Brexit did have an adverse effect on the price volatility of the UK's financial markets.

As stated by Danielsson *et al.*, (2016), it is tempting to say that the initial reactions are nothing but the markets normal reaction to news, however the probability of a consequent increase in systemic crisis, however remote, is certainly not zero. There are some who think that systemic risk will increase due to the large disruptions in the financial markets bought about by Brexit. The main issues seem to be based around two key legal factors: "legal plumbing" and equivalence.

According to Danielsson *et al.*, (2017), the issue of legal plumbing arises when a function such as a settlement or rehypothecation has its legal status questioned. Good examples are the bankruptcy of Lehman Brothers and AIG which intensified the recent financial crisis. Unfortunately, legal timescales operate on a completely different horizon to market participants. Hence should a legal issue arise, the UK and EU government must underwrite the affected activity until a legal solution can be found.

As stated by Danielsson *et al.*, (2017), the issue of legal equivalence arises when any financial organisations operate under the assumption that there is a permanent equivalence agreement that both the UK and EU rules are compliance with each other. Under the UK's membership of the EU, no problems had arisen with regard to interpretation of the rules because the UK's rules were regarded as EU rule and vice-versa. However, when the UK leaves the EU, the assumption is that a permanent equivalence agreement will be agreed. Unfortunately, by their very nature. such agreements are transient; meaning in principle they could be revoked with just a few months' notice.

However, as Danielsson *et al.*, (2017) points, there are others who believe that systemic risk will likely decrease mainly due to the behaviour of market participants under uncertainty and fear and the increase of fragmentation in the financial market. Certainly, as Danielsson *et al.*, (2016) hints, if the UK loses some of its financial sector to the EU be it at a substantial economic cost, the potential benefits are the reduction of the importance of the financial sector on the economy and hence systemic risks. A counter argument, put by Danielsson *et al.*, (2016), is although theoretically both the UK and EU could benefit, however the more likely outcome could be an increase in inefficiency, protectionism and systemic risk and a fall in the quality of financial regulation.

As both Busch & Matthes (2016) and Chang (2017) alludes a key issue is the addition of large levels of uncertainty on the UK's economy which could hinder the confidence of investors and consumers. There is already a danger of financial markets pricing the uncertainties and risks posed by Brexit causing a certain degree of financial turmoil as highlighted by Busch & Matthes (2016). Furthermore, as Busch & Matthes (2016) alludes the rating agencies have hinted of a possible downgrade depending on the negotiations and final agreement. And as Kierzenkowski *et al.*, (2016) hints a hike in economic uncertainty could reduce confident and hence increase risk premiums and cost of finance. According to a survey commissioned by the Centre for Macroeconomics, published on 25 February 2016, amongst its members a significant majority thought there was going to be a hike in volatility as illustrated by Haan *et al.*, (2016). The reasons behind the expectation of a hike in volatility was uncertainty regarding the result of the referendum and implication of Brexit. However, some members disagreed as illustrated by Haan *et al.*, (2016).

Methodology

As stated by Pastor & Stambaugh (2012), conventional wisdom dictates there is a different between the long and short run. Generally, markets are less volatile in the long run due to being less perceptive to shocks; hence they are increasingly stable. As Engle & Lee (1999) states volatility is greater in the short horizon than in the long horizon. This indicates a more rapid short run volatility mean reversion than in the long run as hinted by Engle & Lee (1999). Per Colacito *et al.,* (2011), another important principle often made in economics is the existence of different long and short run sources affecting volatility. Additionally, as de Bondt (2000) hints the price reverts to the fundamental value in the long run. Effectively what de Bondt (2000), Pastor & Stambaugh (2012) and many others like Engle & Lee (1999) are hinting is the reaction of markets participants tend to deviate with time. Another factor, suggested by Engle & Lee (1999), is the different impact from the leverage effect and market risk premium on the market in the short and long run. In a paper written as part of a book in honour of Clive Granger, Engle & Lee (1999) extended the GARCH model to account for the permanent (long run) and transitory (short run) components of volatility deriving the component GARCH model (aka C-GARCH).

It must be remembered that as hinted by Black (1976), a key observation often made in the equity market is the negative correlation between returns and volatility, acknowledged as a leverage effect. Additionally, as indicated by Engle *et al.,* (1987), theory dictate that market participants require increasingly high premium on returns for investing and/or holding increasingly risky assets which is often referred to as the feedback effect.

As previously stated the main aim of this paper is to analyse the impact of Brexit on the stability of the markets in the long and short runs. We extend the variance bound test proposed by Fakhry & Richter (2018) using an asymmetrical C-GARCH-m model, proposed by Engle & Lee (1999). We use the 5% critical value F-statistics to test thestable marketpre-condition hypothesis and hence the efficient market hypothesis. As withFakhry & Richter (2015, 2016a, 2016b, 2018) and Fakhry *et al.*, (2016, 2017), we follow the pre-requisite steps advocated by Shiller (1979, 1981).

1. As illustrated by Shiller (1981), the key factor underlying any variance bound test is the variance calculation. We model the datasets in our test as a time varying lagged variance of the price using equation 1. We used the 5-lagged system, as oppose to the 20-lagged system advocated by Fakhry & Richter (2015).

$$\lim_{t\to T} var(Price_t) = \frac{\sum_{q=1}^{Q}(Price - \mu)^2}{Q} \tag{1}$$

2. As with previous works, Fakhry & Richter (2015, 2016a, 2016b, 2018) and Fakhry *et al.*, (2016, 2017), we estimate the residuals by using a first order autoregressive model as illustrated by equation 2.

$$var(Price_t) = a + b_1 var(Price_{t-1}) + \mu_t \tag{2}$$
$$\mu_t = \tau\mu_{t-1} + \varepsilon_t$$

In a previous paper, Fakhry & Richter (2018) used a first order autoregression model as the underlining equation to the mean section of the GARCH model as illustrated in equation 3.

$$var(Price_t) = a + b_1 var(Price_{t-1}) + \mu_t \tag{3}$$

However, in this paper we are analysing the feedback effect, hence as defined by Engle *et al.*, (1987), we use equation 4.

$$var(Price_t) = \lambda h_{t-1} + a + b_1 var(Price_{t-1}) + \mu_t \quad (4)$$

The key to interpreting the feedback effect is the λ coefficient in equation 4. Thus, a significantly positive λ coefficient hints at a positive feedback effect and suggests that as risk increases the return should increase as well. However, in contrast a significantly negative λ coefficient suggests as risks increases, the returns should decrease. We estimate a first order asymmetrical C-GARCH (1, 1) model to obtain the long run and short run volatility coefficients. It is worth remembering that the GARCH (p, q) model as proposed by Bollerslev (1986) is written as equation 5 where $h_t = \sigma_t^2$ and $k_t = \varepsilon_t^2$

$$h_t = \omega + \alpha_p k_{t-1} + \beta_q h_{t-1} \quad (5)$$

As suggested by Engle & Lee (1999), equation 5 can be slightly transformed into equation 6 where the dynamics of the structure of conditional variance can be illustrated.

$$h_t = \sigma^2 + \left(\alpha_p k_{t-1} - \sigma^2\right) + \left(\beta_q h_{t-1} - \sigma^2\right) \quad (6)$$

The issue is that σ^2 represents the unconditional long run variance. However as argued by Engle & Lee (1999), at the heart of this equation is the question of whether the long run volatility is truly constant over time. Surely, a more flexible specification where the long run volatility is allowed to evolve slowly in an autoregressive manner is a more appropriate model of volatility, given the empirical evidence on time varying and mean reverting volatility as stated by Engle & Lee (1999). A more flexible model would be equations 7 and 8 where by σ^2 is represented by m_t,a time varying long run model of volatility.

$$m_t = \omega + \rho m_{t-1} + \varphi(k_{t-1} - h_{t-1}) \quad (7)$$

$$(h_t - m_t) = \sigma^2 + (\alpha_p k_{t-1} - m_{t-1}) + (\beta_q h_{t-1} - m_{t-1}) \quad (8)$$

Hence, equation 7 is s stochastic representatives of the long run volatility otherwise known as the trend in volatility and equation 8 is the different between the conditional volatility and trend, i.e. the long run volatility. Essentially equation 8 is the short run or transitory volatility.

In essence, this means the dynamics of the volatility components can be interpretedin three steps. Firstly, the short run volatility component is mean reverting to zero at a geometric rate of $(\alpha + \beta)$ under the condition of $0 < (\alpha + \beta) < 1$. Secondly, as highlighted previously the long run volatility component evolves over time in an AR process; conversely if $0 < \rho < 1$ then it will converge to a constant level of $\frac{\omega}{1-\rho}$. The third step is based on the assumption that the long run volatility component has a slow rate of mean reversion than the short run volatility component; simply put, the long run volatility component is the more persistent of the two components meaning $0 < (\alpha + \beta) < \rho < 1$.

We opt to use a single asymmetrical order one lagged C-GARCH model in our tests. Remember the short run volatility component is given by equation 8. The TARCH model as defined by Zakoian (1994) is given by equation 9. Taking equation 9, we could transform it to a single order asymmetrical C-GARCH model by subtracting the long run volatility from each term in the equation to give equation 10. Notice how if the asymmetrical effect is zero the basic model collapses to a C-GARCH model as illustrated by equation 8. A key factor is that the asymmetrical effect is only added to the short run component of the C-GARCH model, see equation 10. This is mainly due to the short life of the asymmetrical effect.

$$h_t = \alpha k_{t-1} + \beta h_{t-1} + \gamma k_{t-1} I \quad (9)$$

$$(h_t - m_t) = \sigma^2 + \left(\alpha_p k_{t-1} - m_{t-1}\right) + \left(\beta_q h_{t-1} - m_{t-1}\right) + \gamma(k_{t-1} - m_{t-1})I \quad (10)$$

$$\text{Where } I = \begin{cases} 0, & \varepsilon_t \geq 0 \\ 1, & \varepsilon_t < 0 \end{cases}$$

Unlike Fakhry & Richter (2015, 2016a, 2016b, 2018), we also illustrate the impact of the asymmetrical effect on the stability of the market. The key is the γ coefficient in equation 10 where $\gamma \neq 0$ then there is an asymmetrical effect; if γ > 0 then there is a leverage effect meaning negative shocks have greater impact than positive shocks. As noted by Engle & Patton (2001), there is a story within any member of the GARCH family of volatility models influenced by the coefficients in thevariance equations. Since as illustrated by Engle & Patton (2001), the market shocks and persistent are indicated by the coefficients α and β, respectively. Therefore, we can deduce that ϕ and ϱ indicate the long run market shocks and persistent, respectively.

The coefficients of the Component-GARCH model of volatility are also key to our variance bound test. As mentioned earlier in this section, we derive our stability test by using the f-statistics; for our observed samples, the f-statistics at the 5% level is 1.96. We calculate our test statistics using equation 11 and 12 as the short run and long run tests of stability respectively.

$$StabilityTest_{SR} = \frac{(\alpha+\beta+\gamma)-1}{standarddeviation \quad (var\,(x))} \leq Fstatistics \quad (11)$$

$$StabilityTest_{LR} = \frac{(\rho+\Phi)-1}{standarddeviation \quad (var\,(x))} \leq Fstatistics \quad (12)$$

In previous work by Fakhry & Richter (2015, 2016a, 2016b, 2018) and Fakhry *et al.*, (2016, 2017), the definition was the market is efficient when the conditions as set in equations 11 and 12 are true. Theoretically, the market is only truly efficient when the StabilityTest statistics is equal to the f-statistic. Hence, we reject the null hypothesis for the EMH if the condition in equations 11 and 12 are true but accept the null hypothesis of the market being too volatile to be efficient for anything else. However, since in this paper the main emphasis is on the stability of the market, therefore we use this test to analyse whether the market is stable or to what extent the market is volatile. The condition given by equations 11 and 12 also state that the market is stable and the variable Stability Test in both equations gives the volatile levels for the long and short runs.

Data description

As stated previously, this paper analyses the stability and thusefficiency of the four major UK financial marketsto establish whether Brexit affected the financial markets. With this in mind, we test the stability and hence efficiency of the equity, FX, gold and sovereign debt markets. As illustrated in table 1, we opt to use the price on the major indices to reflect the British financial market. As with the norm, we choose to use a five-day week filling in the missing data with the last known price.

Table1. *Major British financial markets indices*

Market	Equity	Gold	Foreign Exchange	Sovereign Debt 1	Sovereign Debt 2
Index	FTSE 100		Effective Exchange Rate index, £	UK Gilt Index	
Source	investing.com	World Gold Council	Bank of England	Barclays Capital	S&P4F4F[8]
Modifier	250	25	1	2.5	
Period	08/06/2007–29/12.2017			08/06/2007-23/06/2016	24/06/2016-29/12/2017
Observations	3356			2360	396

It must be noted that like all indices, the four indices are based on weighted ratios of the components prices. The FTSE100 consist of 100 of the largest listed companies on the British equity market each weighted by a given ratio. The Sterling Currency Index 5F5F[9] is calculated daily by the Bank of England using the five major currencies with a weighted ratio: US Dollar, Euro, Japanese Yen, Swiss Franc and Swedish Krona. As hinted by the name, the UK GiltIndex consists of all the government bonds maturities weighted by a ratio. The gold market index is the price of gold weighted by the 3-year GDP in US $.

For reasons noted in footnote 8and as illustrated in table 1, we used two indices to analyse the sovereign debt market over both observational periods. Apart from the sovereign debt market, a key issue with our variance bound test was the standard deviation of the FTSE 100, gold and UK gilt indices variances which caused a problem with the stabilitytest statistics. We tried several methods to resolve the issue, the best solution was to divide the daily index

[8] Due to our inability to get the full observation of the Gilt market, we used the Barclays Index to cover the pre-crises and crises periods and S&P Index to cover the Brexit observational periods.

[9] For a description of the index and how it is calculated see the following Bank of England website: [Retrieved from].

price by the modifier as illustrated by table1 before calculating the five-day variance.

Empirical evidence

As hinted earlier, the keys to the stability and henceEMH test statistics are the coefficients to the variance equation of the volatility model and standard deviation of the observed dataset. Hence in essence the model of volatility estimated determines the statistics. In Fakhry & Richter (2015) and Fakhry *et al.*, (2016, 2017), the estimated model was the GARCH. In Fakhry & Richter (2016a, 2016b), the model used was the GJR-GARCH. The GJR-GARCH had the influential factor of allowing for the analysis of the asymmetrical effect on the EMH. In Fakhry & Richter (2018), the model totest the efficiency in the long and short runs was an asymmetrical variant of the C-GARCH model. We continue to use the asymmetrical effect in this paper; however, in order to extend the analysis of the behavioural factors to include the feedback effect, we use an asymmetrical C-GARCH-m model.

In estimating the models, we used the Marquandt estimation method for all estimations. However, with the error distribution, we used a different distribution model to get the best estimation as illustrated by table 2. For all other options, we used the default settings. Crucially, the system environment may influence the estimation: our system is running EViews 9.5 on a Windows 10 Procomputer with a 10 cores CPU and 32 Gigabytes RAM6F6F[10].

Crisis Period (8th June 2007 - 23rd June 2016)

This period was influenced by a combination of three factors leading to a period of sustained uncertainty and

[10] We tested on a different environment and got slightly different estimation results. However, the variance bound tests were not affected.

highly volatile global financial markets. The financial crisis started with the subprime mortgages in the US and quickly enveloped the global financial sector, for further in-depth research and analysis on the crises see (Brunnermeier, 2009; Caballero & Krishnamurthy, 2009; Masood, 2009) amongst others. The sovereign debt crisis started with the Greek revision of the deficit statistics, gradually becoming a wide spread issue of confident in global fiscal policies enveloping the GIPS nations as illustrated by (Schwarcz, 2011; Metiu, 2011; Mohl & Sondermann, 2013). The crisis reached the US with the deficit/debt ceiling crises which closed the US federal government. The third factor is the causal effect resulting from a deep and costly financial crisis which developed into a deep recession, see (Taylor, 2008; Feldstein, 2009) amongst others for details of the recent economic downturns. An added issue within this period was the confusion and miscommunication by the policy makers which heightened uncertainty during the financial and sovereign debt crisis.

Table 2 seem to be hinting at a significantnegative feedback effect across all markets during the crisis. This seem to be highlighting a change in the risk premium required by the market participants. However, the key to understanding the main impact of the crises in the UK can be obtained from the equity market. The λ coefficient of the equity market is hinting at a significantly large negative feedback effect in relation to the other markets. It must be noted that the equity market was the main source of uncertainty and risk in the UK's financial market throughout the crises period, especially the banking sector.

Table 3.*Statistics for Variance Bound Test using Asymmetrical C-GARCH model7*

Observation period	*Crises: 08/06/2007 – 23/06/2016*				*Brexit: 24/06/2016 – 29/12/2017*			
Market	Equity	Forex	Gold	SD	Equity	Forex	Gold	SD
Distribution	Student's	GED	Normal	Normal	Student's	Student's	Student's	GED
Method	Marquandt	Marquandt	Marquandt	Marquandt	Marquandt	Marquandt	Marquandt	Marquandt
Total Observations	2360				396			
Mean Equation								
λ	-14.61138*	-2.506798*	-7.540547*	-5.204332*	-18.22398*	-0.393644***	-1.734168*	-6.966527*
	(0.833948)	(0.157923)	(0.372064)	(0.088347)	(3.694410)	(0.216195)	(0.335234)	(0.118301)
a	0.012499*	0.029464*	0.007504*	0.045705*	0.006789*	0.038081*	0.008478*	0.044532*
	(0.000113)	(0.000182)	(7.57E-05)	(0.000419)	(0.053051)	(0.001939)	(0.000245)	(0.000968)
b	0.882882*	0.887579*	0.911270*	0.842696*	0.858644*	0.982891*	0.952141*	0.874123*
	(0.001855)	(0.001980)	(0.000793)	(0.000983)	(0.002771)	(0.007903)	(0.007075)	(0.002382)
μ	1.006296*	0.999861*	1.046510*	1.035662*	1.028093*	1.075765*	0.974598*	1.030880*
	(0.002710)	(0.002130)	(0.000468)	(0.001382)	(0.005240)	(0.011609)	(0.010333)	(0.004209)
Volatility Equation								
ω	0.000153***	0.029676	0.000149*	0.001287*	1.88E-05*	0.000948*	-0.000911	0.001205*
	(8.39E-05)	(0.031871)	(1.89E-05)	(0.000134)	(2.98E-06)	(0.000148)	(0.014018)	(0.000191)
Long-run Volatility								
ρ	0.987871*	0.999807*	0.993478*	0.991699*	0.696449*	0.713193*	0.999489*	0.733613*
	(0.005963)	(0.000218)	(0.000698)	(0.000878)	(0.053051)	(0.043864)	(0.004620)	(0.023861)
ϕ	0.22698*	0.127902*	0.140644*	0.086387	0.422920*	0.146804**	0.386175	0.129337*
	(0.032056)	(0.016950)	(0.012887)	(0.002735)	(0.130071)	(0.062024)	(0.413189)	(0.010586)
Short-run Volatility								
α	0.274436*	0.382169*	0.486538*	0.42283*	0.235360***	0.137976	0.340276	0.457846*
	(0.023626)	(0.033525)	(0.007261)	(0.013742)	(0.133692)	(0.092175)	(0.413304)	(0.019318)
γ	-0.257393*	-0.117114*	-0.177517*	-0.318547*	-0.417178*	-0.105734**	0.006011	-0.516112*
	(0.022442)	(0.029772)	(0.005991)	(0.014115)	(0.067039)	(0.048677)	(0.008475)	(0.010576)
β	0.70506*	0.500877*	0.483129*	0.533635*	0.515414*	0.766262*	0.647343	0.093503*
	(0.025432)	(0.045433)	(0.008781)	(0.016916)	(0.131232)	(0.133142)	(0.408035)	(0.030059)

Notes: The numbers in brackets are standard errors, *** indicated 10% p-value significance level, ** is 5% and * is 1%.
The optimal stability statistic is set at the 5% level f-statistic of 1.96.

Table 4.*Statistics for Variance Bound Test using Asymmetrical C-GARCH model7 (Cont.)*

Crises: 08/06/2007 – 23/06/2016				*Brexit: 24/06/2016 – 29/12/2017*	
Equity	Forex	Gold	SD	Equity	Forex
Student's	GED	Normal	Normal	Student's	Student's
Marquandt	Marquandt	Marquandt	Marquandt	Marquandt	Marquandt
2360				396	

Model Statistics					
Log Likelihood	8125.126	5727.662	8495.525	5029.003	1543.342
R^2	0.981631	0.970930	0.975552	0.977924	0.976612
DW-Statistics	1.669845	1.463619	1.549033	1.630397	1.808503
ARCH Effects	0.702242	0.778608	4.718990	1.276436	0.299449
Jarque-Bera	14918.69	41686.10	10565.50	4148.194	1603.041
σ^2	0.105889	0.316246	0.094745	0.289699	0.075373
Stability Tests					
Long Run Stability					
Stability Statistics	2.02902	0.40383	1.41561	0.26954	1.58371

Stability Status	Volatile	Stable	Stable	Stable	Stable
Short Run Stability					
Stability Statistics	2.62442	0.74015	2.19378	1.24986	8.84142
Stability Status	Volatile	Stable	Volatile	Stable	Volatile

Notes: The numbers in brackets are standard errors, *** indicated 10% p-value significance level, ** is 5% and * is 1%.

The volatility has a uniformed long run persistent across all observed markets as highlighted by the ϱ coefficient. This means that the crisis did impactthe long run persistent of volatility in the UK's financial market. The spotlight falls on the significant of the ϕ coefficient in the equity market, this confirms the earlier observation that the main effect of the crisis was on the equity market. The other observed markets all recorded a lesser significantreaction. Part of the reason why is that the remaining three markets were seen as safe haven from the high risks and uncertainties during the crises.

In the short run, the level of the reaction is significant throughout all four observed UK financial markets as illustrated by the α coefficient. However, rather surprisingly the level of reaction to a shock to the market in the gold market issignificant, thus hinting at a highly reactive market environment. Since, the gold market is seen as a solid safe haven commodity market, hence the highly reactive market could be the result offlights from other markets. The β coefficient is hinting at a mixed market with the equitymarket hinting at high level of persistent in the aftermath of a shock to the market in comparison with the other markets. It must be said thatthe equity market was at the centre of the crisis in the UK. The second factor is the Brexit referendum which came towards the end of this observed period, thus hinting at an increasingly significant persistent in the FX market. With respect to the asymmetrical effect, all markets exhibit a negative γ coefficient meaning a leverage effect. However, there is a different in the level of leverage effect with the sovereign debt market showing a significantly high γ coefficient. As noted earlier the leverage effect hint at market participants reacting to negative shocks to the market with greater magnitude than positive shocks. Although globally the observe period was highly reactive with negative market shocks, yet it must be remembered that apart from the financial sector the financial market was not significantly affected by negative shocks during the crises. However, the sovereign debt market was affected by the hike in government debt and deficit plus the drop in key economic indicators, more importantly the downgrading of several sovereign debts during the sovereign debt crisis. In addition, the claims and counter claims regarding the impact of Brexit on the economy during the EU referendum.

Analysing the stability statistics and status fromTable 3, it is worth noting that the impact from the crises only affected theequity market in the long run as previously hinted. Conversely, closer inspection of the stability statistic for the equity market hints at a small different between stability and volatile status with a level of approximately 2.03, it is worth remembering that the optimal stability statistic is set to a f-statistics of 1.96. The other observed markets all accept the conventional wisdom of markets being stable in the long run as argued by Engle & Lee (1990) and De Bondt (2000). The stability test points to a mixed result in the short run with both the FX and sovereign debt markets defying the conventional wisdom that markets tend to be more volatile in the short run as hinted by Engle & Lee (1990) and De Bondt (2000). Thus, the statistics are pointing to the FX and sovereign debt markets being stableand hence accepting the EMH. The remaining two markets hint at the accepted convention of markets being volatile in the short run with levels of approximately 2.6 and 2.2.

Brexit Period (24th June 2016 – 29th December 2017)

As with any big change in any country's direction, the aftermath of the Brexit vote was highlighted by uncertainty and a highly volatile period. Politically, the UK became increasingly unstable especially after a snap general election which was meant to strengthen the hand of the government in the Brexit negotiations resulted in a hang parliament. Economically, as illustrated in the second section, there are huge questions and uncertainties surrounding the economic prospects of the UK during the next few years. Added to these issues, the referendum and Brexit result left a deeply divided country. In the midst of this volatile and uncertain environment, the UK's financial markets must function. The big issue inall thisis the miscommunication, indecision and arguments at the heart of the EU and UK policy making concerning Brexit. Theoretically, this have all the makings of a highly volatile financial market.

Table 3seem to be hinting at a mixed negative feedback effect from the observed markets during the Brexit period as illustrated by the λ coefficient, with the equity and sovereign debt markets showing signs of an increasing impact. However, the gold and FX markets seem to be hinting at a decreasing impact. Surprisingly, the FX markets is more likely hinting at an indifferent feedback effect than a negative effect. However, upon close inspections of the environment, there a number of pointers to the indifferent. The first is that there is a weakness induced by uncertainty in all the major currencies. Secondly, the mixed communication from the EU and British policy makers contradicting each other. The third point is that the British economy seem to be performing much better than expected in the aftermath of the referendum result. However, the most vital point is the uncertainty surrounding a weak British government within a hang parliament.

Other than the gold market, the observed markets are hinting at a reduction in the long-run persistency factor with the ϱ coefficient pointing at relatively large decrease. Although significant on its own when combined with the increase in the ϕcoefficient across all markets hinting at an increase in the reaction to market shocks, this becomes increasingly significant. It must be noted that a weak persistent and strong reaction points to a highly reactive market, hinting at a random walk model behaviour, generally, consistent with a stable market.

Although reduced in significant from the crisis period in all markets except the sovereign debt, the α coefficients still hint at a significant level of market shock reaction in the short run. The persistent in the aftermath of a shock in the short run, as given by β, seem to be hinting at mixed results with the equity and sovereign debt markets hinting at a decrease. The issue is that the sovereign debt is approaching an indifferent persistent during the Brexit period, thus meaning a highly reactive market. In a reversal of the short run persistent analysis, the leverage effect seems to be intensifying in the equity and sovereign debt markets. While the FX and especially gold markets are pointing towards a reversal of the asymmetrical effect. The gold market seems to be hinting at an indifferent asymmetrical effect with the γ coefficient pointing to an insufficient positive asymmetrical effect.

As illustrated by Table 3, during the Brexit period all the observed markets were stable and hence efficient in the long run. This seem to be highlighting that the market participants were pricing the long run impact of Brexit on the financial market and economy. However, the picture is rather splitwith respect to the short run, with the gold and FX markets seemingly stable and efficient. As noted earlier, there is a weakness in the global FX market induced by uncertainty in the economy and political stability. Hence, this may have played a major role in stabilizing the British FX market in the short run. In contrast the equity and sovereign debt markets were volatile and hence inefficient over the short run with levels of 8.84 and 2.75 approximately. As previously hinted, Brexit is likely to have an impact on the economy and trades, hence these two factors have a strong bearing on the equity and sovereign debt markets. The uncertainty and confusions surrounding the economy and any trade deals is being highlighted by the volatile conditions in the two markets with the most significant propensity with these two factors. In reality these two volatile markets are reacting to the market participants evaluation of thenegotiation status and the likely impact on the economy and trade. At the heart of this is the miscommunication by the policy makers on both sides of the Channel. In effect this explains why the gold market isn't volatile because of its global status as a safe haven commodity which means that to a certain extent it isn't affected by Brexit.

Conclusion

In this paper, we introduced the stable market pre-condition hypothesis and used an asymmetrical C-GARCH-m variant of the variance bound test proposed by Fakhry & Richter (2018) to distinguish between the long and short run effect of Brexit on the stability and hence efficiency of the British financial markets. We also analysed the asymmetrical and feedback effect on the financial markets. The results suggest a limited impact on the general financial market going from the global crisis of the late 2000s-mid 2010s to the Brexit process. During the Brexit process, we found that the markets in general were stable in the long run. However, in the short run, we found the results were mixed with two markets hinting at stability.

There is some evidence from the literature and our empirical evidence pointing at a highly volatile impact from the Brexit process, although it does seem to be short lived. Therefore, backing one of the key arguments in the behavioural finance theory, as hinted by De Bondt (2000); market participants sometimes overreact heavily at the initial stages of an event, thus leading to correction in the long run. Like any game changing event, in the immediate time horizon market participants tend to act on little and often conflicting information leading to asymmetrical information and/or a failure in the information system which is reflected in unstable markets in the short run.

Certainly, the evidence from the literature and news is that there is a hint of miscommunication and confusions brought about by the policy makers. This is at the heart ofthe reaction from the market participants. One of the key lessons of the recent global financial and sovereign debt crises is that a percentage of the underlying uncertainty and volatility is linked to political miscommunication, confusion and disjointed action. These three vital factors of volatile markets have seemingly continued during the referendum debate and to a high extent the Brexit process. Based on our findings, we advise all policy makers to make clear and decisive statements and not to engage in tit-for-tat arguments. We also recommend an agreement by all policy makers on both sides to put forward a unified voice and plan. It is essential not to repeat the same mistakes made during the recent crisesand early stages of the Brexit process. Also, we advise the UK policy makers to put forward a decisive and unified plan for the economyin the aftermath of Brexit and effectively communicate it. As illustrated previously by the literature, the economy is and will be the main source of uncertainty in the financial markets at present and for the foreseeable future.

In concluding, it would seem that market participants have already priced the impact of the EU Referendum into the markets in the long run. However, with market participants being humans and hence reactive, any unexpected event in the Brexit process or sign of weakness in the economy during the Brexit process could result in a highly volatile and uncertain financial market. The key in any event and not just Brexit is the information that filters in the aftermath of the event, be it statements or statistics; needs to be collated and more importantly not conflicting, if market are to remain stable.

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5 Happy 20th birthday Euro: An integrated analysis of the stability status in the Eurozone's equity markets

Introduction

Theintroduction of the Euro was probably one of the most significant financial events of the last century, not only because of the introduction of a new currency across the Eurozone but also it contains an influencing concept. At its heart lays a strong ideology in order to prevent conflicts between the countries of Europe, like the first and second world wars, there is a need to integrate the economies and financial markets under one currency and monetary policy. Conversely, on 1st January 1999 the euro was first introduced into 11 countries, hence integrating 11 diverse economies and financial markets under one common monetary union. However, the recent further integration is one of the reasons for the fresh increase in the popularity of the populist/nationalist political movements, especially in the aftermath of the crises and economic downturns, due to the loss of a "national identity" and/or "economic constraints". We introduce a multivariate volatility test using an asymmetrical BEKK MGARCH model first proposed by Engle & Kroner (1995); analysing the stability of the integrated Eurozone financial markets through six different observed periods in the timeline of the euro including the recent rise of populist political movements.

Although, many papers have been written on the impact of the euro on the integration of the financial markets across the Eurozone during the introductory and crises periods. Moreover, there is an extensive library of research on the impact of the euro on the volatility spillover effect and contagious impact of news within the Eurozone. Yet a key issue remains understudied; the stability of the Eurozone markets which was highlighted by the recent financial and sovereign debt crises and extended by the recent rise in the populist political movement, such as the Brexit process or rise of populist political parties, which puts into question the whole concept of European integration.

As argued by Fakhry (2019), since the volatility test indicates that if a market is inefficient then it is deemed to be too volatile to be efficient. Simply put, this means that for a market to be efficient the pre-condition is a measurable stability status. Thus, meaning that essentially the volatility test is a test of the stability pre-condition. In a number of collaborations such as Fakhry & Richter (2016, 2018) using the volatility test, found diverse evidence of market stability in the Eurozone financial markets during the recent global financial and Eurozone sovereign debt crises. While Fakhry (2019) analysing the impact of Brexit on the UK's financial markets found that populism politics could destabilize a market.

Recent studies such as Dotz & Fisher (2011), Metui (2011), Tamakoshi (2011) and Mohl & Sondermann (2013) point to a changing behaviour in the integrated financial market depending on the general market environment. This was confirmed by Fakhry & Richter (2018) who find that the stability of the financial markets may vary among markets and depend on the general environment. Conversely, as illustrated by Pericoli & Sbracia (2003) the evidence on contagion and spillover effects are strong. Furthermore, as noted by Pericoli & Sbracia (2003), this evidence is not limited to countries within a region but there is also evidence of cross regions volatility transmissions. Louzis (2013) also notes the strong evidence of cross markets spillover effects during the crises highlighting the volatility transmission between the stock and sovereign debt markets during the Eurozone sovereign debt crisis.

Although as Christiansen (2007) demonstrated that it is possible to model volatility spillover effects using an univariate GARCH model. Moreover, the VAR as illustrated by Louzis (2013) could be used to identify spillover effects using Diebold & Yilmaz (2012) methodology. Furthermore, as illustrated by Billio & Pelizzon (2003) and Baele (2005), spillover effects can be detected using a multivariate Markov switching model.However, Multivariate GARCH models are more flexible and thus often used in the study of spillover and contagious effects such as (Missio & Watzka, 2011, Favero & Missale, 2011; Groba *et al.,* 2013; MacDonald *et al.,* 2018; Trabelsi & Hmida, 2018).

To this extent, we use an asymmetrical BEKK-MGARCH (aka ABEKK) model to analyse the impact of volatility spillover effect and contagious impact of news on the Eurozone financial markets since the introduction of the euro. We also introduce a multivariate variant of the volatility test to analyse the stability of the environment in the Eurozone financial market. We restrict our analysis by using the EuroStoxx 50 index as the benchmark market, thus meaning we analyse the transmission of volatility and news between each observed equity market and the EuroStoxx 50 index. Using the equity markets from the 10 original members of the Eurozone[1] plus Greece[2] observed from 31st December 1997 to 31st December 2018. Furthermore, we use timeline analysis to research the impact of six different periods associated with the pre-euro, introduction of the euro, mid-2000s global asset price bubble, recent crises (i.e. global financial and Eurozone sovereign debt crises) and rise of populist movement in the last few years.

Our key contribution to the literature on financial econometric is the extension of the volatility test of Fakhry & Richter (2016a) to a multivariate volatility test using an ABEKK model. This would allow us to test the stable market precondition hypothesis, as proposed by Fakhry (2019), in the context of a multivariate environment. Therefore, analysing the environment underpinning the transmission of volatility and news from one market to the other within the Eurozone integrated financial market. Although, the ABEKK have been used to analyse the transmission of volatility such as (Wang & Wang, 2005; Li, 2007; Efimova & Serletis, 2014; Emenike, 2014); yet mainly due to the complex nature of such a model and estimation issues, the ABEKK model has been sparingly used in the context of the Eurozone financial markets integration.

Since as hinted by Bekaert *et al.* (2002) and Baele (2005), a fully integrated market displays interdependency and correlated returns amongst its segments; thus it is one where news contagion and volatility spillover from one segment effects all segments. In general, our results suggest that the market participants within the Eurozone subscribe to the "time and space" effect meaning they tend to react differently to events depending on the time horizon and market. In essence, market participants react differently

[1] As with other researches in the Eurozone, we don't analyse the Luxemburg financial market.

[2] Although Greece did not join until 1st January 2001, yet we feel that Greece is an important market mainly due to the sovereign debt crisis.

according to their affinity to the event. Thus suggesting the Eurozone equity markets was never truly fully integrated.

Given our findings and the latest views on further integration, we recommend a slower pace of integration for the foreseeable future to overcome the loss of national identity which gives rise to extreme views. We also advise the European parliament to communicate more with the population in order to raise awareness of the work and concept of the European Union. A key issue raised by the recent crises within the Eurozone and the European Union is miscommunication, we recommend the setup of a committee to oversee the communication and actions during any event.

We follow the convention by firstly reviewing the literature on the Eurozone financial markets integration. Secondly, we review the methodology of the model specifications of the ABEKK MGARCH and our multivariate volatility test. Thirdly, we review our observed data. The fourth section provides our empirical evidence on the stability of the Eurozone integrated equity markets, analysing the volatility spillover effects and impact of contagious news over six periods during the timeline of the euro. Concluding with the conclusions and recommendations.

A literature review of the Eurozone's integrated financial markets

In order to understand the impact of the spillover and contagion effects, we need to research the impact of integration on the Eurozone equity market. Baele *et al.* (2004) defines an integrated financial market as a market for financial instruments and services where all market participants are governed by three principle characteristics:

1. a single set of rules regarding the purchase or selling of instrument or services.
2. equal access to instruments and services.

3. equal treatment for all market participants engage in a market.

As stated by Baele *et al.* (2004), economic theory dictate that the integration and development of financial markets are key to economic growth in the Eurozone by removing frictions and barriers and allocating capital more efficiently. However, a key issue is taken a step too far financial integration could be detrimental to market competition as highlighted by Baele *et al.* (2004). Further, a key argument made by Baele *et al.* (2004) is that financial integration may affect the structure and hence have implication for the stability of the financial system.

According to Cohen (2003) many economists and academics predicted the Euro will challenge the dollar for global supremacy, for many at the time the question was not if but when. Relatively few, such as Feldstein (1997), questioned the enthusiasm towards the new currency. As quoted by Cohen (2003, p.576), many predicted "*a rosy future*" for the new currency. However, according to Cohen (2003) there were four major obstacles standing in front of the euro challenging the dollar as the global currency at the time: firstly, the persistent inertia behaviour of monetary systems. Secondly, the cost of doing business in euros. Thirdly, the "anti-growth" bias built into EMU and finally the ambiguous governance structure of the EMU. Although as Cohen (2003) states these obstacles could be overcome. Conversely, Papaioannou *et al.* (2006) found that the influence of the Euro as the reference international reserve currency of the central banking environment was growing and accordingly "*Punching above its weight*".

Ehrmann & Fratzscher (2002) found in the immediate aftermath of the introduction of the euro macroeconomic news from the US had more impact on the Eurozone financial markets than vice-versa. However, the importance of macroeconomic news, especially the M3 monetary levels and CPI, from the Eurozone grew in the later stages of the Euro's introduction period.

Reviewing the impact of the euro on the financial markets after one year, Danthine *et al.* (2000) found evidence illustrating the euro did have an immediate impact on the Eurozone financial markets. However, the impact was not mainly due to the elimination of currency risk but a result of indirect feedback mechanisms. These feedback mechanisms include the cross-country transaction costs, liquidity of the Eurozone's financial markets, diversification opportunities available for Eurozone investors and institutional changes effecting the banking sector.

As Trichet (2001) states the euro had a huge impact on the Eurozone's financial markets. Across the board, the Eurozone financial markets grew in the aftermath of the introduction of the euro. A key factor in the equity market was the growth in mergers and acquisitions totalling over $1trillion during the initial two years of the euro. An important factor in this is the trend towards the merger or cooperation between stock exchanges i.e. the Euronext stock exchange which was created by the merger of the exchanges in Paris, Brussels and Amsterdam. In the aftermath of the introduction of the euro, the total market capitalisation of the Eurozone's equity market stood at €5.5 trillion in 1999 as oppose to €3.6 trillion in 1998. According to Trichet (2001). The contributory factors to this growth are not only the rise in price but also the IPO of private companies. However, as Trichet (2001) states there were still some barriers to further integration of the Eurozone's financial markets; hinting at the Lisbon meeting of the European Council in March 2000 as a landmark in the integration of the European financial markets.

Conversely, in a study of the impact of the euro on the European financial markets after four years, Galati & Tsatsaronis (2003) noted the impact is uneven across the spectrum of the financial market. In many respects the euro have had a positive impact i.e. the redirection of prices in the equity market to reflect industry risk factors as oppose to country risk factors and lower cross border transaction barriers. These positive impacts have enhanced the ability for investors to build pan-European strategies and portfolios. However, Galati & Tsatsaronis (2003) found there were still issues with implications on financial markets integration; like the focus on narrowly defined interests meaning the potential of European Monetary Union to integrate financial markets may not be fully realised. Another issue highlighted is diverged legal and institutional infrastructures and market practices which may impede on further development of the Eurozone financial markets.

According to Fratzscher (2001), European equity markets have become increasingly integrated since 1996. This integration is largely driven by EMU and is at the heart of the Eurozone's equity market overtaking the US equity market within Europe. Furthermore, Baele *et al.* (2004) found evidence hinting at an increasingly integrated equity market pointing at three key elements of the Eurozone financial markets:

- The advantages of sector diversification have surpassed those of country diversification.
- Equity returns are increasingly determined by common news factors.
- The decrease in home bias within financial institutions' portfolios.

Moreover, the results from Hardouvelis *et al.* (2006) points at diminishing forwards interest differentials against the German benchmark and inflation differentials have been key to the integration of the equity markets during the 1990s. Significantly, the exception was the UK's equity market. Conversely, Lane & Walti (2006) found evidence pointing at strong bilateral financial linkages within the Eurozone.

However, the results seem to suggest that there are other factors than EMU also driving the financial integration.

Nevertheless, Cappiello *et al.* (2006) found the integration of Eurozone equity markets was not as strong as the bond markets and was determined by the size of the economy with integration being greater in the large economies. And as Bekaert *et al.* (2013) found that it is EU membership rather than euro adoption that have increased financial integration. Thus, meaning European equity markets segmentation decreased with EU membership.

An important issue in this paper is the study of the spillover and contagion effects on the Eurozone financial market. Much of the empirical evidence in the past few years have concentrated on the spillover and contagion effect on the Eurozone sovereign debt market during the crises of the late 2000s to mid-2010s. Good examples of recent research in spillover and contagion effects in the Eurozone sovereign debt markets during the crises are Missio & Watzka (2011), Favero & Missale (2011) and Groba *et al.* (2013). Since this paper is partly researching and analysing the volatility spillover and news contagion of the Eurozone equity market, therefore we will provide empirical evidence on the equity market.

In essence as stated by Groba *et al.* (2013), a vital factor in the behaviour of volatility in any financial market is the transmission of volatility from one asset or market to another; often referred to as the volatility spillover effect. The introduction of the VEC by Bollerslev *et al.* (1988) was aimed at the co-movement in the time varying volatility between two or more assets or markets. The BEKK introduced by Engle & Kroner (1995) had the advantage of the conditional covariance matrices being positive definite by construction as stated by Silvennoinen & Terasvirta (2008). However as hinted by Silvennoinen & Terasvirta (2008) a major problem is due to the number of parameters required in the BEKK; the sheer computing power was prohibiting on most computers. This meant convergence using the BEKK model was and still is difficult.

Using a multivariate regime switching model and world and German indices as benchmarks markets, Billio & Pelizzon (2003) found volatility spillover increased from both benchmarks to most European equity markets since the introduction of the Euro. Furthermore, introducing a regime-dependent shock spillover intensities variant of the Markov switching model, Baele (2005) hints at an increase in intensity in the spillover effects for the European Union throughout the 1980s and 1990s. The key contributory factors are increased trade integration, equity market development and low inflation. Moreover, Baele (2005) found some evidence of contagion during highly volatile periods.

Missio & Watzka (2011) use a DCC multivariate GARCH model to analyse the contagion effect of sovereign debt credit ratings during the Eurozone sovereign debt crisis in seven Eurozone yield spreads. They use the announcements on the Greek credit ratings to analyse the financial contagion between the Greek market and the other observed yield spreads. The results hint at a strong financial contagion from the credit ratings announcement, especially around the first bailout of the Greek economy during the summer of 2010. Furthermore, the results imply contagion only effect economically or politically unstable countries. Similarly, Groba *et al.* (2013) using the BEKK model on CDS from EU members found a varied transmission of risk from the GIPSI[3] countries to other EU members during the crises period. Like Missio & Watzka (2011), the results hint at a fragmentation of the EU between financial distressed members and other members.

[3] GIPSI are Greece, Italy, Portugal, Spain and Ireland

Louzis (2013) constructed spillover indices based on Diebold & Yilmaz (2012) framework which uses a generalised decomposition of the forecast-error variance of a VAR model. In general, they found a high level of return and volatility spillover effect over the observed markets. Moreover, the equity market was the largest transmitter of return and volatility spillover, even during the recent sovereign debt crisis.

MacDonald *et al.* (2018) using a BEKK model found that the direction and intensity of the spillover effect is time dependent. Although the GIPSI nations are occasionally the largest contributors of the spillover effects, however the core Eurozone countries also transmit volatility to the GIPSI. Conversely, the results point to the existence of cluster of countries, hence the spillover effect comes from within the group ((i.e. Core or Periphery). Moreover, Trabelsi & Hmida (2018) using a DCC-MGARCH model and a limited number of Eurozone equity markets showed during the recent financial crisis there was the existence of contagion between all observed markets. However, the results from the sovereign debt crisis points to only Greece and Portugal being impacted by contagion.

Methodology

The importance of a stable environment underpinning the Eurozone financial markets was underlined during the crises period as illustrated by any number of researches during the last few years such as Groba *et al.* (2013), MacDonald *et al.* (2018) and Trabelsi & Hmida (2018). The impact of volatility spillover and contagion of news from one market to the other market within the Eurozone is a hot debate that is just as relevant today as it was during the crises and euro introductory periods. Therefore, we extend the volatility test proposed by Fakhry & Richter (2016a) to a multivariate volatility test using an asymmetrical BEKK-MGARCH model proposed by Engle & Kroner (1995). We use the 5% critical value F-statistics to test the stable market pre-condition hypothesis. As with Fakhry & Richter (2016, 2018), we follow the key pre-requisite step advocated by Shiller (1979, 1981).

As illustrated by Shiller (1981), the key factor underlying any volatility test is the variance calculation. We model the datasets in our test as a time varying lagged variance of the price using equation 1. We used the 5-lagged system as advocated by Fakhry & Richter (2016a)

$$\lim_{t \to T} var\left(Price_{i,t}\right) = \frac{\sum_{q=1}^{Q}\left(Price_{\,i,q} - \mu_i\right)^2}{Q} \qquad (1)$$

However, since we are only concerned with the stability of the transmissions of volatility between the markets and thus the integration of the Eurozone markets; we don't follow step 2 of Shiller (1981) estimating the residuals using an autoregression model.

Model specifications for the ABEKK bivariate GARCH

As illustrated by Christiansen (2007) and Ball (2009) among others, a key factor in the behaviour of volatility is the influence of volatility from related external sources. And while the volatility spillover effect could be estimated using a univariate GARCH model as demonstrated by Christiansen (2007) thru the use of a three-step technique. Yet we think that a more elegant method to our observed data would be to use a multivariate GARCH model. There are a number of MGARCH models as surveyed by Bauwens *et al.* (2006) and Silvennoinen & Terasvirta (2008); chief among these models are the BEKK-MGARCH (Engle & Kroner, 1995) and DCC-MGARCH (Engle, 2002). We use theABEKK model to model the conditional covariance of our observed equity market indices.

One of the key contributions of our research is the use of a bi-variate ABEKK model. As hinted previously, we differ from previous research into the integration of the Eurozone markets in that we use the EuroStoxx 50 index as the benchmark equity market. Thus, analysing the spillover and contagion effects between the benchmark and observed11 Eurozone members in all six stages of the Euro's timeline.

The reasoning behind our choice of the ABEKK is the restrictions of the other MGARCH models in order to guarantee the positivity of the conditional covariance, thus rendering our results unusable. In order to overcome these restrictions, we chose to use the unrestricted BEKK model. However, the big issue with using any unrestricted BEKK model is the large number of parameters and thus computing power required. In a normal BEKK, each coefficient matrices have a $N \times N$ number of parametersplus a C matrix has $\frac{N(N+1)}{2}$ parameters and lastly there are the N parameters for the mean equation. However, we are using the more complicated ABEKK which adds an asymmetrical matrix, D, with $N \times N$ parameters. With this number of parameters, it is highly likely that one reason why the unrestricted ABEKK have been used sparingly in econometric research is the sheer computing power it requires. Another possible issue with the unrestricted ABEKK is the difficulty to get convergence.

Our single lag ABEKK (1, 1) would be modelled using equations 2 and 3.

Mean Equation

$$\mu = \mu_{Euro} + \mu_i \qquad (2)$$

Covariance Equation

$$H_t = CC' + Au_{t-1}u'_{t-1}A' + BH_{t-1}B' + Dv_{t-1}v'_{t-1}D' \qquad (3)$$

where

$$v_{t-1} = u_{t-1}{}^{\circ}I_{u<0}u_{t-1},\ u_{t-1} = [u_{euro\,,t-1}u_{i,t-1}]' \text{ and } v_{t-1} = [v_{euro\,,t-1}v_{i,t-1}]'$$

H_t *and* H_{t-1} is the conditional covariance at time t or t-1
u_{t-1} is the conditional residuals at time t-1
C is the constant term
A is the coefficient matrix of the conditional residuals or ARCH
B is the coefficient matrix of the conditional covariance or GARCH
D is the coefficient matrix of the asymmetrical effect

Since, we are using a bi-variate system to test the transmission of news and volatility between the euro index and the other Eurozone indices. The generalised matrix system is as in equation 4.

$$C = \begin{vmatrix} \omega_{11} & \omega_{12} \\ 0 & \omega_{22} \end{vmatrix},\ A = \begin{vmatrix} \alpha_{11} & \alpha_{12} \\ \alpha_{21} & \alpha_{22} \end{vmatrix},\ B = \begin{vmatrix} \beta_{11} & \beta_{12} \\ \beta_{21} & \beta_{22} \end{vmatrix},\ D = \begin{vmatrix} \gamma_{11} & \gamma_{12} \\ \gamma_{21} & \gamma_{22} \end{vmatrix} \tag{4}$$

Therefore, when our model is split into its component parts, we can write the components using equations 5-7.

Variance of the Euro equity market benchmark

$$h_{1,t} = C(1,1)^2 + A(1,1)^2u_{1,t-1}^2 + 2A(1,1)A(2,1)u_{1,t-1}u_{2,t-1} + A(2,1)^2u_{2,t-1}^2 + B(1,1)^2h_{1,t-1} + 2B(1,1)B(2,1)\sigma_{(1,2),t-1} + B(2,1)^2h_{2,t-1} + D(1,2)^2v_{1,t-1}^2 + 2D(1,1)D(2,1)v_{1,t-1}v_{2,t-1} + D(2,1)^2v_{2,t-1}^2 \tag{5}$$

Variance of the i^th^ Eurozone market

$$h_{2,t} = C(2,1)^2 + C(2,2)^2 + A(1,2)^2 u_{1,t-1}^2 + 2A(1,2)A(2,2)u_{1,t-1}u_{2,t-1} + A(2,2)^2 u_{2,t-1}^2 + B(1,2)^2 h_{1,t-1} + 2B(1,2)B(2,2)\sigma_{(1,2),t-1} + B(2,2)^2 h_{t-1} + D(1,2)^2 v_{1,t-1}^2 + 2D(1,2)D(2,2)v_{1,t-1}v_{2,t-1} + D(2,2)^2 v_{2,t-1}^2 \quad (6)$$

Covariance of the Euro and i[th] Eurozone equity markets

$$\sigma_{(1,2),t} = C(1,1)C(2,1) + A(1,1)A(1,2)u_{1,t-1}^2 + \big(A(1,2)A(2,1) + A(1,1)A(2,2)\big)u_{1,t-1}u_{2,t-1} + A(2,1)A(2,2)u_{2,t-1}^2 + B(1,1)B(1,2)h_{1,t-1} + \big(B(1,2)B(2,1) + B(1,1)B(2,2)\big)\sigma_{(1,2),t-1} + B(2,1)B(2,2)h_{1,t-1} + D(1,1)D(1,2)v_{1,t-1}^2 + \big(D(1,2)D(2,1) + D(1,1)D(2,2)\big)v_{1,t-1}v_{2,t-1} + D(2,1)D(2,2)v_{2,t-1}^2 \quad (7)$$

Under our ABEKK specification, the conditional covariance is estimated using equation 3. It is worth noting that the general equation dictates that the conditional covariance at time t depends on the conditional covariance and the product of the residuals multiplied by the inverse residuals at time t-1.However, the key point is the three $N(N+1)$ coefficient matrices and the raw coefficient matrices. These represent the constant, ARCH and GARCH coefficients in the ABEKK.

Of importance is the matrices A, B and D as highlighted in equation 4.Since we are only interested in the transmission between two markets, the key to the interpretation is the off-diagonal coefficients in all three matrices. As intended by Engle & Kroner (1995), the key to interpreting the ABEKK lays in the three matrices coefficients: A,B and D. Furthermore, as hinted by Engle &

Kroner (1995), these coefficients translate into the market shock and volatility transmissions from one market to the next. Put simply, as Kim *et al.* (2015) and MacDonald *et al.* (2018) states the A matrix coefficient reflects the "*news contagion effect*" and the B matrix coefficient represents the "*volatility spillover effect*". Thus, meaning that a statistically significant value for A(m, n) can be interpreted as the impact of news from market m onmarket n. In the same way, a statistically significant value in the B(m, n) coefficient may be interpreted as the volatility spillover between markets m and n. As intended by Engle & Kroner (1995), the standard ABEKK implies that only the magnitude of the past returns is important in determining the current conditional covariance. Hence, we only need to use the magnitude of the A and B matrices coefficients to interpret the news and volatility spillover effects. Interestingly, the asymmetrical effect, matric D, could be interpreted as the impact of news from market m on the volatility of market n. In other words, a leverage effect is the transmission of bad news from market m to the volatility of market n. Since the leverage effect captures the transmission of bad news, it is logical to say that a positive asymmetrical effect could be interpreted as the transmission of good news from market m to the volatility of market n.

Specification of the multivariate volatility test

The coefficients of the ABEKK model of volatility are also key to our multivariate volatility test. It is essential to note that like Fakhry (2019), we use our volatility test to analyse whether the market is stable or volatile. As mentioned earlier in this section, we derive our stability test by using the f-statistics; for our observed samples, the f-statistics at the 5% level is 1.96. We calculate our stability test statistics using equations 8 and 9 as the stability status of the transmission. Since as stated earlier, we are only interested in the transmission of volatility from the benchmark euro market to market n and vice-versa, thus we only used the off-diagonal matrices.

$$Stability\ Test_{Euro \rightarrow n} = \frac{(A_{Euro,n} + B_{Euro,n} + D_{Euro,n}) - 1}{sdev(var(Euro)) + sdev(var(n))} \leq Fstatistics \quad (8)$$

$$Stability\ Test_{Euro \leftarrow n} = \frac{(A_{n,Euro} + B_{n,Euro} + D_{n,Euro}) - 1}{sdev(var(Euro)) + sdev(var(n))} \leq Fstatistic \quad (9)$$

Like the univariate volatility test of Fakhry & Richter (2016a), our multivariate volatility test consists of three coefficients: A, B, and D matrices representing the news contagion, volatility spillover and asymmetrical effects. However, since we are analysing a multivariate model of volatility, we use a two-factor denominator representing the standard deviations of the euro benchmark and Eurozone markets.

Data description

Essentially, this paper analyses the stability of the integrated equity markets from the 11 original Eurozone members to establish the impact of key periods in the life of the euro on the Eurozone financial markets against a Eurozone benchmark market. Hence, we use daily prices from the 11 equity markets listed plus the EuroStoxx 50 as the benchmark equity market obtained from investing.com. As with the norm, we chose to use a five-day week filling the missing data with the last known prices. With the exception of the Portuguese PSI 20 index, all the 11 remaining markets were observed between 31st December 1997 and 31st December 2018 meaning a total of 5,479 observations. However, the Portuguese PSI 20 index was observed from 4th January 1999 making a total of 5,216 observations.

Table 5. *Major Eurozone equity markets Indices*

Market	*Eurozone*	*Austria*	*Belgium*	*Finland*	*France*	*Germany*	*Greece*	*Ireland*	*Italy*	*Holland*	*Portugal*	*Spain*
Index	EuroStoxx 50	ATX	BEL 20	OMX H 25	CAC 50	DAX	ATHEX LC	ISEQ OA	MIB	AEX	PSI 20	IBEX 35

It must be noted that like all indices, the observed equity markets are based on weighted ratios of their component's prices. In common with many researches using the volatility test, such as Fakhry & Richter (2018), we used a modifier of 25 on the prices to overcome an issue with the variance calculations.

Empirical evidence

As hinted earlier, the key variables to our multivariate test of the stability in the Eurozone equity markets lay with the coefficients of the co-variance model and two standard deviation statistics. Essentially, this means the model of volatility is the key, we use a bi-variate ABEKK-MGARCH model. Thus, meaning we analyse the news contagious effect, volatility spillover effect and asymmetrical effect by interpreting the A, B and D matrices respectively. It is worth noting as stated earlier since we are only interested in the transmission effect from one market to the other market, we only report the off-diagonal matrices.

In estimating the models, we used the BFGS estimation method for all estimations. However, with the error distribution, we opted to use a mixture of normal and t-student distribution models to get the best estimation as illustrated by tables 2 to 7. For all other options, we used the default settings. Crucially, the system environment may influence the estimation: our system is running Estima WinRATS Pro (64-bit) 9.20e on a Windows 10 Pro computer with a 10 cores CPU and 32 Gigabytes RAM[4].

[4] It is possible to have slightly different estimation results in different environments. However, the volatility tests should not be affected.

Pre-Euro

During the period immediately before the introduction of the euro, the markets were split between enthusiasm and nervousness about the introduction of the euro. As hinted by Cohen (2003), relatively few questioned the enthusiasm; indeed, many predicted a rosy future. However, the markets were still slightly apprehensive about the introduction of the euro as highlighted by Bates (1999) and as stated by McCauley & White (1997) there were still many uncertainties surrounding EMU. And as Feldstein (1997) hints the fear was that EMU would lead to disagreements among the member states as for the right policies for a given circumstance. The other key issue during this period was the uncertainty bought about by the Russian default and LTCM Crises during the latter half of 1998 see (Dungey *et al.*, 2007; Lowenstein, 2000).

Table 6. *Stability Test for Pre-Euro Period (07/01/1998 - 31/12/1998)*

Market i	*ATX*	*BEL 20*	*OMX H 25*	*CAC 40*	*DAX*	*ATHEX LC*	*ISEQ Overall*	*MIB*	*AEX*	*IBEX 35*
Distribution	t-Student	Normal	Normal	Normal	Normal	Normal	Normal	Normal	t-Student	Normal
					Mean Statistics					
μ_{Euro}	8.2772E-02	7.1454E-02	7.5285E-02	8.4374E-02	8.6885E-02	8.2504E-02	9.1931E-02	5.9678E-02	8.7844E-02	7.9791E-02
	(7.551E-03)	(1.085E-02)	(6.321E-03)	(2.944E-05)	(8.532E-03)	(6.920E-03)	(8.534E-03)	(5.248E-03)	(7.382E-03)	(6.495E-03)
μ_i	9.0271E-03	3.8159E-02	1.7895E-02	1.4127E-01	2.5395E-01	4.2959E+00	1.5790E-01	2.7400E+00	2.1924E-03	1.1026E+00
	(1.235E-03)	(7.121E-03)	(1.365E-03)	(6.961E-03)	(3.660E-02)	(5.211E-01)	(1.711E-02)	(2.487E-01)	(1.656E-04)	(7.339E-02)
					Off Diagonal Co-Variance Statistics					
$A_{Euro, i}$	7.8386E-03	1.1957E-01	1.0417E-01	3.5509E-01	1.9995E+00	9.8435E+00	3.6564E-01	7.0437E+00	-9.0920E-05	3.6220E+00
	(6.691E-03)	(3.438E-02)	(1.544E-02)	(1.062E-01)	(2.845E-01)	(2.447E+00)	(7.837E-02)	(1.307E+00)	(4.590E-03)	(5.703E-01)
$A_{i, Euro}$	4.4204E-01	5.7976E-02	-5.3502E-02	1.2466E-01	-2.1521E-03	2.9895E-04	-2.8240E-02	-1.5726E-04	8.8016E+00	1.1438E-02
	(3.532E-01)	(7.275E-02)	(1.074E-01)	(5.568E-02)	(3.091E-02)	(4.692E-04)	(2.454E-02)	(1.339E-03)	(4.672E+00)	(5.165E-03)
$B_{Euro, i}$	7.2789E-03	-1.5334E-02	6.4176E-02	1.0647E-01	-2.4874E+00	-2.1172E+01	-2.1927E-01	2.4303E+00	-3.7133E-03	-3.2495E+00
	(8.114E-03)	(5.060E-02)	(1.415E-02)	(1.880E-01)	(3.171E-01)	(4.358E+00)	(9.152E-02)	(1.975E+00)	(3.403E-03)	(1.039E+00)
$B_{i, Euro}$	-1.1902E+00	9.1726E-02	-4.1121E-01	-8.3653E-02	-3.3513E-02	-2.5386E-03	1.2321E-01	-1.8348E-04	-1.0063E+01	-4.1190E-02
	(3.986E-01)	(9.398E-02)	(1.493E-01)	(1.280E-01)	(4.135E-02)	(9.750E-04)	(3.076E-02)	(2.070E-03)	(2.933E+00)	(7.338E-03)
$D_{Euro, i}$	-1.0000E-08	-4.4191E-02	3.2120E-01	-3.8847E-01	8.6483E-02	-2.1540E-05	-5.4125E-01	-5.2347E+01	2.8721E-02	-1.5695E+01
	(1.385E-01)	(2.864E-01)	(1.040E-01)	(6.874E-01)	(3.474E+00)	(2.722E+01)	(6.648E-01)	(2.362E+01)	(1.687E-02)	(5.170E+00)
$D_{i, Euro}$	7.8000E-07	1.6633E+00	-1.7586E-01	-4.7382E-01	1.0721E-02	3.0000E-08	4.9852E-01	1.5029E-02	5.7256E+01	1.1236E-01
	(1.316E+01)	(9.374E-01)	(3.860E+00)	(1.945E-01)	(4.285E-01)	(6.368E-03)	(2.080E-01)	(1.192E-02)	(4.408E+01)	(2.875E-02)
					Model Statistics					
Log-Likelihood	783.8487	387.0287	592.7830	318.7714	53.5277	-840.8711	2,079.6663	-567.2480	1,341.8880	-336.1376
Final Criterion	5.60E-06	6.80E-06	4.10E-06	0.00E+00	9.00E-06	8.90E-06	2.70E-06	9.50E-06	4.80E-06	6.70E-06
					Co-integration Volatility Test					
σ^2_{Euro}	0.327011									
σ^2_i	0.045969	0.248090	0.086727	0.448785	1.003011	18.007491	0.709850	8.700593	0.009436	3.918915
					Stability Test ($Market_{Euro} \rightarrow Market_i$)					
Statistics $_{(Euro, i)}$	2.6406	1.6344	1.2338	1.1948	1.0537	0.6724	1.3453	4.8599	2.8982	3.8442
Status $_{(Euro, i)}$	Volatile	Stable	Stable	Stable	Stable	Stable	Stable	Volatile	Volatile	Volatile
					Stability Test ($Market_{Euro} \leftarrow Market_i$)					
Statistics $_{(i, Euro)}$	4.6871	1.4137	3.9653	1.8469	0.7706	0.0547	0.3921	0.1091	163.4568	0.2161
Status $_{(i, Euro)}$	Volatile	Stable	Volatile	Stable	Stable	Stable	Stable	Stable	Volatile	Stable

As explained in the methodology, the A matrices pick up the transmission of news. Hence a statistically significant $A_{Euro\,,i}$ matrix would be interpreted as the impact of news from the EuroStoxx on the Eurozone equity markets and vice-versa. As illustrated by

Table 6, with the exception of the ATX and AEX, during the immediate pre-euro period news from the EuroStoxx had a significant impact on all the Eurozone markets giving a ratio of 8:2. However, news from the Eurozone markets did not have a significant impact on the EuroStoxx with the exception of the ATX, CAC and AEX intimating a ratio of 3:7. The B matrices indicate the volatility spillover effect, hence a statistically significant $B_{Euro\,,i}$ would be interpreted as the transmission of volatility from the EuroStoxx to the Eurozone markets.

Table 6 seem to be hinting at six Eurozone markets being affected by the transmission of volatility from the EuroStoxx: CAC, DAX, ATHEX, ISEQ, MIB and IBEX hinting at a ratio of 6:4. Conversely, the EuroStoxx was affected by volatility from four Eurozone markets: AIX, OMXH, ISEQ and AEX suggesting a ratio of 4:6. As defined in the methodology, the D matrices is the asymmetrical effect; thus, in short indicates whether the transmitted news is good or bad. The results from the immediate pre-euro period seem to be hinting at a 7:3 transmission of bad news from the EuroStoxx to the Eurozone markets (ATX, BEL, CAC, ATHEX, ISEQ, MIB and IBEX). Furthermore, there is a 2:8 transmission of bad news from the Eurozone markets to the EuroStoxx with only the OMXH and CAC. The stability status of the transmission between the EuroStoxx and Eurozone markets seem to be hinting at a ratio of 6:4 with four markets being volatile: ATX, MIB, AEX and IBEX. Whereas the stability status of the transmission from the Eurozone markets to EuroStoxx is hinting at a ratio of 7:3 with the ATX, OMXH and AEX being volatile.

The introduction of the Euro

As highlighted earlier in the paper, the introduction of the euro bought about a phase of improved environment in the Eurozone financial markets as illustrated by (Danthine *et al.*, 2000; Trichet, 2001). However, as Galati &Tsatsaronis (2003) notes the impact was uneven across the spectrum of the Eurozone financial markets. Nevertheless, EMU did have a huge impact on the integration of the European financial markets, especially within the Eurozone as illustrated by (Fratzscher, 2001; Baele *et al.*, 2004; Lane & Walti, 2006).

On another note, the impact from other events should not be overlooked; especially the war on terror which was initiated by the September 2001 attacks see (Chen & Siems, 2004; Johnston & Nedelescu, 2006) and the accountancy issues of 2002 which led to the bankruptcy of Enron and WorldCom see (Benston & Hartgraves, 2002; Sidak, 2003; Brickey, 2002).

As illustrated by Table **7**, the advent of the Euro reduced the impact of news from the EuroStoxx on the Eurozone markets to five markets: DAX, ATHEX, ISEQ, PSI and IBEX. However, the impact of news from the Eurozone markets on the EuroStoxx did increased to five markets: ATX, BEL, OMXH, CAC and AEX. Thus the ratio for both news routes is 5:6.

With the exception of the (ATX, BEL, OMXH AEX and PSI), there was volatility spillover effect between the EuroStoxx and Eurozone market meaning a volatility transmission ratio of 6:5. However, the volatility spillover effect from the Eurozone markets to the EuroStoxx was less significant with only four markets being affected: ATX, CAC, DAX and AEX; giving a ratio of 4:7.

The results seem to be hinting at the EuroStoxx transmitting bad news to six Eurozone markets: BEL, OMXH, CAC, DAX, MIB and AEX; thus indicating a ratio of 6:5. Conversely, the transmission of bad news to EuroStoxx point to five Eurozone markets: BEL, DAX, ATHEX, AEX and IBEX giving a ratio of 5:6.

The stability status of the transmission between the EuroStoxx and Eurozone markets seem to be hinting at a ratio of 8:3 with three markets being volatile: ATX, CAC and AEX. Whereas the stability status of the transmission from the Eurozone markets to EuroStoxx is hinting at a ratio of 9:2 with only the ATX and AEX being volatile.

Table 7.*Stability Test for Euro Introductory Period (01/01/1999 - 11/03/2003)*

Market	*ATX*	*BEL 20*	*OMX H 25*	*CAC 40*	*DAX*	*ATHEX LC*	*ISEQ Overall*	*MIB*	*AEX*	*PSI 20*	*IBEX 35*
Distribution	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal	GED	t-Student	Normal
Mean Statistics											
μ_{Euro}	1.8252E-01	1.4888E-01	1.4110E-01	1.5519E-01	1.5313E-01	1.8019E-01	1.6551E-01	1.3417E-01	1.3906E-01	1.5414E-01	1.5393E-01
	(7.867E-03)	(6.998E-03)	(7.656E-03)	(7.554E-03)	(4.139E-03)	(9.692E-03)	(6.451E-03)	(6.953E-03)	(6.565E-03)	(5.883E-03)	(7.585E-03)
μ_i	4.6904E-03	2.6802E-02	1.3354E-02	2.1369E-01	3.5177E-01	1.1734E+00	1.1992E-01	1.4151E+00	2.2808E-03	2.9903E-01	7.5780E-01
	(2.440E-06)	(2.350E-03)	(1.396E-03)	(1.139E-02)	(6.991E-04)	(7.584E-02)	(9.560E-05)	(9.810E-02)	(1.298E-04)	(1.655E-02)	(3.360E-02)
Off Diagonal Co-Variance Statistics											
$A_{Euro, i}$	4.7540E-03	1.8235E-02	-5.3600E-03	-8.5587E-02	4.6463E-01	3.3138E-01	1.8626E-01	8.1012E-02	2.5535E-03	2.2861E-01	1.7249E-01
	(5.859E-04)	(6.076E-03)	(3.339E-03)	(8.764E-02)	(8.680E-02)	(1.975E-01)	(2.020E-02)	(3.579E-01)	(5.108E-04)	(5.895E-02)	(1.279E-01)
$A_{i, Euro}$	2.0066E+00	5.2074E-01	3.5355E-01	1.4034E-01	3.0446E-02	4.2181E-04	4.6515E-02	1.8756E-02	6.0038E+00	1.7293E-02	2.9867E-02
	(4.803E-01)	(6.693E-02)	(3.447E-02)	(3.868E-02)	(1.477E-02)	(2.306E-04)	(1.342E-02)	(2.958E-03)	(2.288E+00)	(4.728E-03)	(5.768E-03)
$B_{Euro, i}$	-4.6450E-03	-9.2278E-04	1.3913E-02	-9.1728E-01	4.8271E-01	-3.5863E-01	-1.2253E-01	1.8753E+00	1.8722E-03	-9.2672E-03	-1.5536E+00
	(1.178E-03)	(8.106E-03)	(4.359E-03)	(1.292E-01)	(1.078E-01)	(3.531E-01)	(5.028E-02)	(7.457E-01)	(6.672E-04)	(6.524E-02)	(2.651E-01)
$B_{i, Euro}$	2.7084E+00	5.0942E-02	-9.3450E-02	2.6438E-01	-1.0712E-01	2.7433E-04	4.7274E-02	-2.3768E-03	-3.6474E+01	8.8741E-03	9.8045E-03
	(7.156E-01)	(7.082E-02)	(3.050E-02)	(5.818E-02)	(3.467E-02)	(2.337E-04)	(2.595E-02)	(4.772E-03)	(2.438E+00)	(6.050E-03)	(8.634E-03)
$D_{Euro, i}$	2.6443E-02	-5.8937E-05	-5.0000E-09	-4.7228E-01	-1.1603E+00	1.1339E+01	1.2842E+00	-5.1636E+00	-3.1791E-03	1.9384E+00	6.1840E+00
	(6.750E-03)	(3.144E-01)	(6.113E-02)	(6.798E-01)	(7.285E-01)	(2.628E+00)	(1.628E-01)	(3.550E+00)	(3.604E-03)	(9.347E-01)	(9.942E-01)
$D_{i, Euro}$	3.1656E+01	-1.5430E-03	1.2500E-07	1.2236E-01	-2.2348E-02	-7.0240E-02	3.5434E-01	2.4081E-03	-5.1675E+01	3.2060E-01	-6.1823E-02
	(5.756E+00)	(8.231E+00)	(1.534E+00)	(2.386E-01)	(1.455E-01)	(2.399E-02)	(2.623E-01)	(2.070E-02)	(1.432E+01)	(2.116E-01)	(5.292E-02)
Model Statistics											
Log-Likelihood	3,587.0507	1,144.9582	1,202.1530	492.5994	-320.1671	-3,933.0375	-55.2916	-2,299.9445	5,302.0649	-965.6877	-1,485.9866
Final Criterion	0.00E+00	0.00E+00	2.00E-07	2.90E-06	0.00E+00	7.20E-06	0.00E+00	1.80E-06	8.00E-06	1.70E-06	3.10E-06
Co-integration Volatility Test											
σ^2_{Euro}	0.406660										
σ^2_{Market}	0.015024	0.218365	0.340313	0.642757	0.861218	33.759090	0.585550	5.335929	0.007623	2.250696	2.319631
Stability Test (Market$_{Euro}$→Market$_i$)											
Statistics	2.3085	1.5723	1.3273	2.3586	0.9567	0.3018	0.3506	0.7326	2.4108	0.4357	1.3949
Status	Volatile	Stable	Stable	Volatile	Stable	Stable	Stable	Stable	Volatile	Stable	Stable
Stability Test (Market$_{Euro}$←Market$_i$)											
Statistics	83.8807	0.6877	0.9905	0.4507	0.8668	0.0313	0.5562	0.1709	200.6969	0.2458	0.3749
Status	Volatile	Stable	Stable	Stable	Stable	Stable	Stable	Stable	Volatile	Stable	Stable

Note:PSI 20 start 11/01/1999

Mid 2000s Global bull market

In accordance with Pagan & Sossounov (2003), we set a trend to be a financial market period of four or more month. Thus, allowing us to identify the mid-2000s global bull equity market to be between March 2003 and October 2007 using the monthly MCSI World index obtained from investing.com. Furthermore, this observation seems to match the trend in the monthly EuroStoxx 50 index as illustrated by Figure 2.

However, another key factor shaping the financial markets in the mid-2000s was the housing bubble primarily in the US which started in 2002 according to Baker (2008). This led to the increase in Mortgage Backed Securities and Collateralized Debt Obligationas hinted by Masood (2009). As hinted by Fender & Kiff (2004), these securities were by their nature complicated to understand and rate. Furthermore, according to Masood (2009), these securities included subprime mortgages which offered a high positive spread with respect to the yields offered by most governments' bonds mainly due to the inherent high risks.

In addition, as highlighted previously, the continuation of "war on terror" was a key issue with the invasion of Afghanistan and Iraq as illustrated by (Johnston & Nedelescu, 2006; Fernandez, 2008).

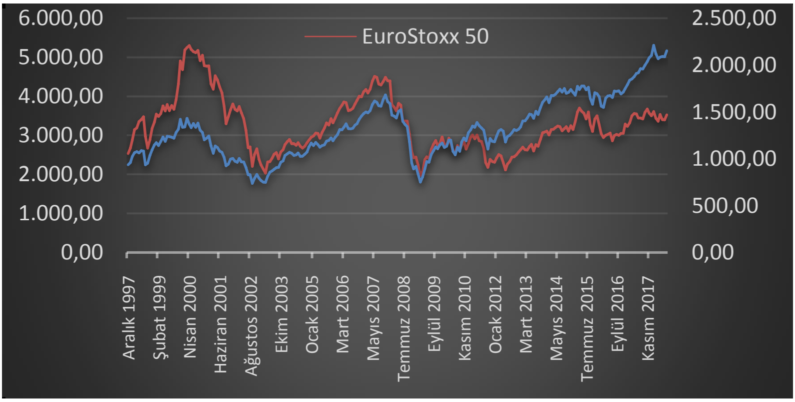

Figure 2. *Trends in Global and Eurozone Equities Markets*

During the mid-2000s global bull market, news from the EuroStoxx impacted only three Eurozone markets: CAC, ATHEX and IBEX as noted by Table 8. Furthermore, news from only four Eurozone markets had an impact on the

EuroStoxx: ATX, BEL, OMXH and AEX. Therefore giving ratios 3:8 and 4:7 respectively.

Table 8. *Stability Test for Mid-2000s Global Bull Market Period (12/03/2003 - 07/06/2007)*

Market	*ATX*	*BEL 20*	*OMX H 25*	*CAC 40*	*DAX*	*ATHEX LC*	*ISEQ Overall*	*MIB*	*AEX*	*PSI 20*	*IBEX 35*
Distribution	Normal	Normal	Normal	t-Student	Normal	Normal	Normal	t-Student	t-Student	Normal	t-Student
Mean Statistics											
μ_{Euro}	2.8179E-02	2.5382E-02	2.5183E-02	2.5341E-02	2.4339E-02	3.1600E-02	3.9000E-02	1.7084E-02	2.3764E-02	3.6367E-02	2.4057E-02
	(1.699E-03)	(1.410E-03)	(1.536E-03)	(1.057E-03)	(1.400E-03)	(1.954E-03)	(1.733E-03)	(8.304E-04)	(9.356E-04)	(1.651E-03)	(1.046E-03)
μ_i	8.7332E-03	1.0806E-02	7.9069E-03	4.4584E-02	6.4174E-02	9.7231E-01	8.1666E-02	1.0390E+00	3.6375E-04	4.5643E-02	1.7456E-01
	(6.749E-04)	(4.482E-05)	(5.228E-04)	(1.823E-03)	(3.484E-03)	(8.125E-02)	(3.580E-03)	(5.560E-02)	(1.396E-05)	(3.409E-03)	(7.162E-03)
Off Diagonal Co-Variance Statistics											
$A_{Euro,i}$	8.4322E-03	7.1397E-02	2.4996E-03	1.3745E-01	8.3948E-02	1.2917E+00	6.2738E-03	-3.7205E-04	2.2310E-03	1.0155E-02	3.8146E-01
	(4.068E-03)	(2.509E-02)	(7.366E-03)	(1.593E-01)	(9.174E-02)	(5.074E-01)	(4.511E-02)	(8.567E-01)	(8.160E-04)	(3.699E-02)	(2.694E-01)
$A_{i,Euro}$	1.6481E-01	3.9793E-01	3.4202E-01	6.5284E-02	6.1610E-02	2.9739E-03	-7.8290E-03	-1.0430E-05	4.7370E+00	2.4023E-02	-1.1681E-03
	(1.417E-02)	(4.434E-02)	(4.564E-02)	(5.524E-02)	(1.463E-02)	(4.129E-04)	(4.685E-03)	(3.940E-06)	(2.512E+00)	(5.122E-03)	(2.718E-03)
$B_{Euro,i}$	4.0547E-03	-2.8218E-01	-6.1637E-02	5.6985E-01	-2.0216E-01	6.5935E-01	-2.4951E-01	-3.7671E-01	-1.5034E-03	2.6707E-02	-5.5080E-01
	(4.930E-03)	(5.596E-02)	(7.153E-03)	(1.688E-01)	(1.428E-01)	(6.011E-01)	(6.414E-02)	(3.408E-01)	(1.391E-03)	(3.377E-02)	(3.018E-01)
$B_{i,Euro}$	5.0791E-02	4.9401E-01	2.3582E-01	-2.2975E-01	-1.4657E-02	-8.4500E-06	1.2306E-01	-6.3000E-07	7.4661E+00	7.1277E-03	8.7832E-03
	(1.209E-02)	(1.209E-01)	(5.493E-02)	(6.086E-02)	(2.810E-02)	(4.258E-04)	(4.675E-03)	(1.680E-06)	(4.293E+00)	(4.590E-03)	(4.031E-03)
$D_{Euro,i}$	7.6479E-01	3.4302E-01	-2.0205E-02	9.4788E-01	1.3840E-06	8.4700E-06	1.6924E+00	9.4636E+01	-6.5039E-03	3.2132E-02	-4.8602E+00
	(1.027E-01)	(2.086E-01)	(1.566E-01)	(1.051E+00)	(9.515E-01)	(1.140E+01)	(3.758E-01)	(6.180E+01)	(1.148E-02)	(4.763E-01)	(5.422E+00)
$D_{i,Euro}$	4.7651E+00	5.2221E-01	-1.5219E+00	2.5993E-01	-2.4000E-08	0.0000E+00	1.9882E-01	1.1085E-02	6.7994E+00	-3.8397E-01	-1.5832E-02
	(9.462E-01)	(8.853E-01)	(1.027E+00)	(3.249E-01)	(1.676E-01)	(8.738E-03)	(8.170E-02)	(1.277E-02)	(3.035E+01)	(2.041E-01)	(4.284E-02)
Model Statistics											
Log-Likelihood	3,430.6909	3,971.7453	4,429.3204	4,379.5326	3,220.4664	-948.3656	1,743.7585	-403.4603	9,147.5749	1,824.7063	1,958.1198
Final Criterion	6.00E-07	9.10E-06	6.40E-06	8.50E-06	2.90E-06	3.20E-06	4.10E-06	3.70E-06	7.00E-07	2.10E-06	1.30E-06
Co-integration Volatility Test											
σ^2_{Euro}	0.125478										
σ^2_{Market}	0.254822	0.129432	0.069595	0.226895	0.295208	6.676128	0.688531	377.490365	0.002580	0.515531	1.147335
Stability Test (Market$_{Euro}$→Market$_i$)											
Statistics	0.5856	3.4042	5.5330	1.8593	2.6581	0.1398	0.5518	0.2470	7.8541	1.4524	4.7372
Status	Stable	Volatile	Volatile	Stable	Volatile	Stable	Stable	Stable	Volatile	Stable	Volatile
Stability Test (Market$_{Euro}$←Market$_i$)											
Statistics	10.4671	1.6247	9.9658	2.5670	2.2655	0.1466	0.8427	0.0026	140.5812	2.1104	0.7921
Status	Volatile	Stable	Volatile	Volatile	Volatile	Stable	Stable	Stable	Volatile	Volatile	Stable

With the exception of the (ATX, OMXH AEX and PSI), there was volatility spillover effect between the EuroStoxx and Eurozone markets indicating a ratio of 7:4. However, there was a volatility spillover effect from five Eurozone markets to the EuroStoxx: BEL, OMXH, CAC, ISEQ and AEX. This would hint at a ratio of 5:6.

The results seem to be hinting at the EuroStoxx transmitting bad news to three Eurozone markets: OMXH, AEX and IBEX. Conversely, the transmission of bad news to EuroStoxx point to four Eurozone markets: OMXH, DAX, PSI and IBEX. Moreover hinting at ratios of 3:8 and 4:7 respectively.

The stability status of the transmission between the EuroStoxx and Eurozone markets seem to be hinting at a ratio of 6:5 with five markets being volatile: BEL, OMXH, DAX, AEX and IBEX. Yet, the stability status of the transmission from the Eurozone markets to EuroStoxx is hinting at a ratio of 5:6 with the ATX, OMXH, CAC, DAX, AEX and PSI being volatile.

Global financial crises

The global financial crisis started with the subprime mortgages in the US and quickly enveloped the global financial sector. By mid-2007, a number of international banks (e.g. Bear Stearns and BNP Paribas) recorded losses on their off-balance sheet activities associated with the MBS or CDO securities, which resulted in flights to liquidity and quality. This quickly enveloped the global financial sector including many European banks such as Credit Agricole and Deutsche Bank. As the global financial crisis spread, the credit market froze therefore corporations could not find the money required and hence the crisis spread to the equity and corporate bonds market. For further in-depth research and analysis on the crises see (Brunnermeier, 2009; Caballero & Krishnamurthy, 2009; Masood, 2009) amongst others. Conversely, it is important to analyse the equity market during the global financial crisis. A by-product of such a global financial crisis is the inevitable deep recession which for the Eurozone was between 2008 Q1 and 2009 Q2, however some countries in the Eurozone were affected more than others i.e. the GIPS nations.

During the global financial crisis, with the exceptions of three markets (BEL, ISEQ and AEX); news from EuroStoxx impacted the Eurozone markets as Table 9 points. Yet, news from only two Eurozone markets had an impact on the EuroStoxx: BEL and AEX. Hence indicating ratios of 8:3 and 2:9 respectively.

With the exception of the (DAX and AEX), there was volatility spillover effect between the EuroStoxx and Eurozone markets indicating a ratio of 9:2. However, there was a volatility spillover effect from four Eurozone markets to the EuroStoxx: BEL, OMXH, CAC and AEX. Therefore giving a ratio of 4:7.

The results seem to be hinting at the EuroStoxx transmitting bad news to two Eurozone markets: OMXH and ATHEX meaning a ratio of 2:9. Conversely, the transmission of bad news to EuroStoxx point to four Eurozone markets: BEL, DAX, ISEQ and PSI hinting at a 4:7 ratio.

The stability status of the transmission between the EuroStoxx and Eurozone markets seem to be hinting at a ratio of 8:3 with three markets being volatile: OMXH, CAC and AEX, Conversely, the stability status of the transmission from the Eurozone markets to EuroStoxx is hinting at a ratio of 10:1 with only the AEX being volatile.

Table 9. *Stability Test for Global Financial Crises Period (08/06/2007 - 05/11/2009)*

Market	ATX	BEL 20	OMX H 25	CAC 40	DAX	ATHEX LC	ISEQ Overall	MIB	AEX	PSI 20	IBEX 35
istribution	Normal	Normal	Normal	Normal	Normal	Normal	Normal	GED	t-Student	Normal	t-Student
Mean Statistics											
μ_{Euro}	1.0306E-01	9.3310E-02	1.1560E-01	9.2224E-02	9.9391E-02	1.1885E-01	9.1467E-02	7.9555E-02	8.2856E-02	1.1402E-01	8.3285E-02
	(1.051E-02)	(6.749E-03)	(6.117E-03)	(7.933E-03)	(1.209E-04)	(6.056E-03)	(6.809E-03)	(7.591E-03)	(4.614E-03)	(5.490E-03)	(4.383E-03)
μ_i	1.3520E-01	4.5951E-02	8.1944E-02	1.6728E-01	3.8709E-01	4.0273E+00	1.2301E-01	6.3790E+00	9.1593E-04	4.2448E-01	1.1301E+00
	(1.640E-02)	(5.042E-03)	(4.351E-03)	(1.306E-02)	(8.073E-03)	(7.344E-03)	(1.263E-02)	(4.612E-01)	(4.941E-05)	(2.449E-02)	(6.337E-02)
Off Diagonal Co-Variance Statistics											
$A_{Euro,i}$	1.6405E-01	-2.6559E-02	1.2682E-01	1.4315E-01	4.8452E-01	3.5128E+00	6.2091E-02	6.0859E+00	1.0901E-04	1.0367E-01	1.4484E+00
	(6.181E-02)	(3.285E-02)	(2.691E-02)	(1.979E-01)	(6.311E-02)	(1.102E+00)	(9.051E-02)	(5.146E+00)	(9.727E-04)	(2.140E-01)	(7.615E-01)
$A_{i,Euro}$	7.6418E-02	2.0537E-01	-3.3607E-02	6.7159E-02	1.1676E-02	2.2338E-03	2.5186E-02	1.9633E-03	9.6908E+00	1.9035E-02	1.0073E-02
	(2.577E-02)	(3.590E-02)	(6.888E-02)	(5.052E-02)	(6.375E-03)	(5.879E-04)	(4.321E-03)	(8.036E-04)	(2.848E+00)	(4.017E-03)	(4.660E-03)
$B_{Euro,i}$	1.9014E-01	3.6701E-01	-1.5753E-01	-2.5126E+00	-3.3933E-02	1.4576E+00	2.2907E-01	-2.8125E+01	1.6861E-03	2.2507E+00	-2.2166E+00
	(3.335E-01)	(6.256E-02)	(2.863E-02)	(1.846E-01)	(3.272E-01)	(1.561E+00)	(1.152E-01)	(7.401E+00)	(9.355E-04)	(3.333E-01)	(9.632E-01)
$B_{i,Euro}$	-9.9805E-02	-3.3214E-01	2.5727E-01	6.5892E-01	-7.3459E-02	-1.7825E-03	-4.1211E-03	8.0086E-03	-5.4876E-01	-4.0419E-02	1.7872E-02
	(1.200E-01)	(4.762E-02)	(9.630E-02)	(6.167E-02)	(1.806E-02)	(8.737E-04)	(3.599E-03)	(7.816E-04)	(3.406E+00)	(4.894E-03)	(6.184E-03)
$D_{Euro,i}$	4.2000E-08	4.3180E-01	-3.4880E-01	6.1678E-01	9.6932E-01	-3.6223E+01	2.2373E+00	2.9644E+01	1.7578E-02	1.6400E-07	1.0852E+01
	(3.133E-01)	(2.684E-01)	(2.116E-01)	(6.747E-01)	(1.293E+00)	(8.189E+00)	(9.615E-01)	(3.359E+01)	(6.357E-03)	(1.115E+00)	(5.358E+00)
$D_{i,Euro}$	5.6000E-07	-3.2998E-02	1.4771E+00	1.4696E-01	-3.4274E-01	2.0133E-02	-7.5545E-01	2.9785E-03	2.0524E+01	-1.1000E-08	6.8087E-02
	(2.595E-01)	(5.810E-01)	(2.993E-01)	(2.590E-01)	(7.854E-02)	(6.933E-03)	(2.929E-01)	(4.941E-03)	(7.114E+01)	(1.003E-01)	(2.485E-02)
Model Statistics											
Log-Likelihood	300.6691	742.1833	931.2756	798.1102	264.2771	-1,865.7951	-377.1802	-1,786.5661	3,652.2827	-591.0954	-621.9875
Final Criterion	4.10E-06	8.90E-06	8.60E-06	2.30E-06	0.00E+00	3.70E-06	2.80E-06	9.00E-06	3.30E-06	3.00E-06	0.00E+00
Co-integration Volatility Test											
σ^2_{Euro}	0.452223										
σ^2_{Market}	0.630372	0.419485	0.190188	0.744926	1.633878	17.450001	1.692385	29.480684	0.006635	3.083772	6.090440
Stability Test ($Market_{Euro} \rightarrow Market_i$)											
Statistics	0.5965	0.2613	2.1474	2.2993	0.2013	1.8016	0.7127	0.2207	2.1371	0.3830	1.3884
Status	Stable	Stable	Volatile	Volatile	Stable	Stable	Stable	Stable	Volatile	Stable	Stable
Stability Test ($Market_{Euro} \leftarrow Market_i$)											
Statistics	0.9453	1.3305	1.0909	0.1061	0.6733	0.0547	0.8087	0.0330	62.4718	0.2889	0.1382
Status	Stable	Stable	Stable	Stable	Stable	Stable	Stable	Stable	Volatile	Stable	Stable

Sovereign debt crisis

The sovereign debt crisis started with the Greek revision of the deficit statistics on 5th November 2009, gradually becoming a wide spread issue of confident in global fiscal policies enveloping a number of Eurozone nations especially the GIPS nations as illustrated by (Schwarcz, 2011; Metiu, 2011; Mohl & Sondermann, 2013). The crisis reached the US with the deficit/debt ceiling crises which closed the US federal government, see (Aye *et al.*, 2016; Nippani & Smith, 2014). The impact from the sovereign debt crisis led to a double dip recession in the Eurozone from 2011 Q3 to 2013 Q1, although for some Eurozone countries this was just a continuation of the recession that followed the global financial crisis.

During the sovereign debt crisis, news from EuroStoxx impacted eight Eurozone markets; with the exception of the BEL, ISEQ and AEX, every Eurozone market was affected as hinted by Table 10. Yet, news from only two Eurozone markets had an impact on the EuroStoxx: BEL and AEX. Surprisingly, the news transmission did not involve the GIPS markets. However, the ratios do tell a varied story with 8:3 and 2:9 respectively.

With the exception of the AEX and PSI, there was volatility spillover effect between the EuroStoxx and Eurozone markets indicating a ratio of 9:2. However, there was a volatility spillover effect from five Eurozone markets to the EuroStoxx: ATX, BEL, OMXH, CAC and AEX. Thus meaning a ratio of 5:6.

The results seem to be hinting at the EuroStoxx transmitting bad news to five Eurozone markets: ATX, OMXH, CAC, ISEQ and PSI. Conversely, there was transmission of bad news to EuroStoxx from the OMXH, CAC, DAX and ATHEX markets. This seem to be indicating ratios of 5:6 and 4:7 respectively.

Table 10. *Stability Test for Eurozone Sovereign Debt Crises Period (06/11/2009 - 23/05/2014)*

Market	*ATX*	*BEL 20*	*OMX H 25*	*CAC 40*	*DAX*	*ATHEX LC*	*ISEQ Overal.*	*MIB*	*AEX*	*PSI 20*	*IBEX 35*
Distribution	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal
Mean Statistics											
μ_{Euro}	4.2214E-02	4.3411E-02	4.4181E-02	4.0793E-02	3.7419E-02	4.5479E-02	4.6584E-02	3.8975E-02	3.8686E-02	4.4333E-02	4.4682E-02
	(7.597E-05)	(1.916E-03)	(2.037E-03)	(1.758E-03)	(1.746E-03)	(2.039E-03)	(2.130E-03)	(1.764E-03)	(1.848E-03)	(2.000E-03)	(1.820E-03)
μ_i	4.1706E-02	2.6321E-02	3.8216E-02	7.5143E-02	2.3663E-01	3.4170E-01	5.7336E-02	2.5418E+00	4.1851E-04	1.6396E-01	6.3992E-01
	(1.538E-03)	(1.307E-03)	(1.789E-03)	(3.302E-03)	(1.213E-02)	(1.689E-02)	(2.833E-03)	(1.091E-01)	(2.246E-05)	(1.215E-02)	(2.675E-02)
Off Diagonal Co-Variance Statistics											
$A_{Euro,i}$	1.0900E-01	3.6479E-02	1.0474E-01	2.0161E-01	5.2311E-01	7.8490E-01	7.2979E-02	1.3068E+00	1.1437E-03	6.7880E-01	-9.5931E-01
	(2.443E-02)	(2.921E-02)	(2.035E-02)	(1.406E-01)	(1.469E-01)	(1.349E-01)	(2.385E-02)	(2.028E+00)	(3.746E-04)	(1.158E-01)	(5.145E-01)
$A_{i,Euro}$	9.8249E-02	1.8070E-01	7.9670E-02	9.1798E-02	1.0966E-03	2.2790E-03	4.8118E-02	3.1065E-03	7.7313E+00	2.7663E-02	1.2245E-02
	(2.704E-02)	(5.300E-02)	(2.756E-02)	(4.066E-02)	(4.932E-03)	(6.294E-04)	(1.413E-02)	(4.503E-04)	(3.281E+00)	(2.945E-03)	(1.613E-03)
$B_{Euro,i}$	-2.7845E-01	-2.3045E-01	-2.5995E-01	-5.7131E-01	-1.5299E-01	-8.0178E-01	-2.2053E-01	-1.6886E+01	-3.1681E-04	5.0368E-02	1.1253E+01
	(4.339E-02)	(6.853E-02)	(2.800E-02)	(2.026E-01)	(1.541E-01)	(1.934E-01)	(3.398E-02)	(5.171E+00)	(6.616E-04)	(1.721E-01)	(8.378E-01)
$B_{i,Euro}$	2.0417E-01	4.8208E-01	-1.3146E-01	-1.5341E-01	9.0305E-03	1.5469E-03	2.0764E-02	2.2508E-03	1.3918E+01	7.4351E-03	-2.4606E-02
	(4.275E-02)	(1.589E-01)	(0.000E+00)	(6.510E-02)	(4.775E-03)	(6.042E-04)	(2.060E-02)	(1.467E-03)	(4.377E+00)	(3.696E-03)	(2.920E-03)
$D_{Euro,i}$	-2.8138E-01	7.3576E-02	-1.6930E-06	-5.1480E-06	2.1350E-06	2.1350E-06	-1.7266E-01	2.5327E+01	0.0000E+00	-3.9973E+00	3.9239E-01
	(2.450E-01)	(1.813E-01)	(1.607E-01)	(7.397E-01)	(1.151E+00)	(1.151E+00)	(2.825E-01)	(1.449E+01)	(2.811E-03)	(1.175E+00)	(1.983E+01)
$D_{i,Euro}$	1.0298E+00	5.0410E-01	-2.9590E-06	-3.4610E-05	-1.1000E-07	-1.1000E-07	5.0595E-01	1.5599E-02	2.9000E-07	1.1728E-02	1.5643E-03
	(1.603E-01)	(6.086E-01)	(2.612E-01)	(3.537E-01)	(3.188E-02)	(3.188E-02)	(1.979E-01)	(3.061E-03)	(2.944E+01)	(6.312E-02)	(8.010E-02)
Model Statistics											
Log-Likelihood	3,260.4049	4,034.0831	3,431.8634	3,571.6650	1,365.2570	-349.4377	2,686.5624	-1,375.5705	8,904.9819	764.7998	109.0727
Final Criterion	1.60E-06	1.70E-06	2.00E-06	0.00E+00	9.00E-07	5.10E-06	6.70E-06	4.60E-06	1.20E-06	7.20E-06	6.90E-06
Co-integration Volatility Test											
σ^2_{Euro}	0.162061										
σ^2_{Market}	0.173969	0.111005	0.120255	0.296825	1.044217	4.723441	0.203134	10.875993	0.001786	1.179788	3.082813
Stability Test ($Market_{Euro} \rightarrow Market_i$)											
Statistics	4.3176	4.1030	4.0919	2.9848	0.5222	0.2081	3.6151	0.7926	6.0982	3.1808	2.9849
Status	Volatile	Volatile	Volatile	Volatile	Stable	Stable	Volatile	Stable	Volatile	Volatile	Volatile
Stability Test ($Market_{Euro} \leftarrow Market_i$)											
Statistics	0.9885	0.6112	3.7256	2.3135	0.8206	0.2039	1.1642	0.0887	126.0313	0.7103	0.3115
Status	Stable	Stable	Volatile	Volatile	Stable	Stable	Stable	Stable	Volatile	Stable	Stable

The stability status of the transmission between the EuroStoxx and Eurozone markets seem to be hinting at a ratio of 3:8 with eight markets being volatile: ATX, BEL, OMXH, CAC, ISEQ, AEX, PSI and IBEX. Conversely, the stability status of the transmission from the Eurozone markets to EuroStoxx is hinting at a ratio of 8:3 with the OMXH, CAC and AEX being volatile.

Rise of populist movement

A key issue facing any further integration of the Eurozone is the rise of the populist right-wing movement. As hinted by Weyland (2001), traditionally populism has been defined as a cumulative concept, characterized by the simultaneous presence of political, economic, social, and discursive attributes. However, as hinted by a number of articles including (Mudde, 2004; Mudde & Kaltwasser, 2013; Jansen, 2011) populism is difficult to define. Indeed, as with any ism word it is hard to conceptualised as stated by Jansen (2011) leading to Mudde (2004, p. 542) to state the following" *Definingthe Undefinable*". Many authors have used different definition depending on their writings. Mudde (2004) defines populism as "*an ideology that considers society to be ultimately separated into two homogeneous and antagonistic groups, 'the pure people' versus 'the corrupt elite', and which argues that politics should be an expression of the volonté générale (general will) of the people.*"

Whichever definition you used, the rise of the populist movement is seen as a threat to the further integration of the EU and Eurozone economies and financial markets as hinted by Polyakova & Fligstein (2016), Fligstein *et al.* (2012), Guiso *et al.* (2018) and Luo (2017). The underlying influences of the Brexit results and prospective Italexit have been attributed to the populist movement in both the UK and Italy caused by deep issues as illustrated by (Inglehart & Norris, 2016; Hobolt, 2016; Codogno & Galli, 2017). In particular as the

Franco-German axis is the driving force behind European integration, the rise in popularity and strength of National Rally (an anti-Integration party) in France would be seen as a weakness in the future push to further integration. And as put by Luo (2017, p. 407) "*The growth of Euroscepticism in major EU members thus has resulted in political instability to European integration.*" Moreover, as implied by Luo (2017), the European Parliament elections in May 2014 was a watershed event for this rise. Although, many like Mudde[5] and Mudde (2016), disagree with the significant of the 2014 European Parliament elections. Yet we use the day after the 2014 European Parliament elections, 26 May 2014, as the start date of our observation.

Furthermore, the continued impact of the Brexit vote on the Eurozone equity markets as the UK and EU struggle to get a workable agreement that would suit both sides and more importantly get approval from both parliaments. According to Hobolt (2016), in the wake of the 23 June 2016 Brexit vote global equity markets loss over two trillion dollars. The reaction on 24th June 2016 of the Eurozone equity markets illustrated the shock wave to the Brexit vote as shown by Figure 3. With the exception of Finland, the losses were greater than 5% meaning an average of 8.17% across all 12 observed Eurozone equity markets. With the current draft agreement[6] in the balance, the continued disfunction at the heart of the British government look likely to negatively impact on the global and hence the Eurozone equity markets in the short run.

Moreover, an additional impact on the integration of the Eurozone came on 1st October 2017 when Catalonia held a

[5] In an article to the Washington Post on 30/05/2014 titled "The far right in the 2014 European Elections: of earthquakes, cartels and designer fascists."

[6] The draft agreement document number TF50 (2018) 55 agreed on 14 November 2018. the agreement could be accessed on [Retrieved from].

referendum on independence from Spain as highlighted by Cetra & Lineira (2018). According to Cetra & Lineira (2018), the turnout was only 43% resulting in a 90.2% vote for independence against 7.8%. The Spanish government declared the referendum illegal. However, as stated by Cetra & Lineira (2018), this was not the only bid for independence within the European Union, in 2014 the UK government agreed a referendum on Scottish independence. The turnout was 99.91% resulting in a 55.3% win for the unionists. However, as argued by Cetra & Lineira (2018), with the Brexit results many in Scotland feel there is a need to hold a new referendum. Furthermore, according to Cetra & Lineira (2018), there are other regions within the EU and in particular the Eurozone who are calling for independence.

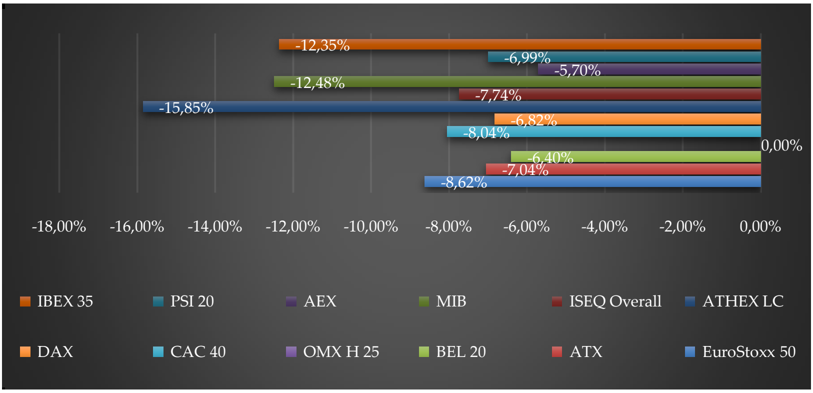

Figure 3. *Impact of Brexit Vote on the Eurozone Equity Markets on 24 June 2016*

Table 11 seem to be hinting at news from the EuroStoxx effecting seven markets during this period with the exception of the ATX, BEL, ATHEX and AEX, all the markets were effected. However, the news from only two markets, BEL and AEX, did have an impact on the EuroStoxx. Thus resulting in ratios of 7:4 and 2:9 respectively.

With the exception of four markets: ATX, BEL, OMXH and AEX; there was a volatility spillover effect between the EuroStoxx and Eurozone markets hinting at a ratio of 7:4. However, the transmission of volatility between the Eurozone markets and EuroStoxx impacted five markets: BEL, OMXH, CAC, ATHEX and AEX. Hence, the ratio was 5:6.

The statistics indicate a ratio of 7:4 effected by negative news from the EuroStoxx with the exceptions being the ATX, OMXH, ATHEX and PSI. With the exception of three Eurozone markets: OMXH, MIB and AEX; the EuroStoxx was effected by the transmission of negative news which gives a ratio of 8:3.

The stability status of the transmission between the EuroStoxx and Eurozone markets seem to be hinting at a ratio of 7:4 with seven markets being volatile: ATX, BEL, OMXH, CAC, DAX, MIB and AEX. Conversely, the stability status of the transmission from the Eurozone markets to EuroStoxx is hinting at a ratio of 6:5 with the ATX, BEL, OMXH, CAC, ATHEX and AEX being volatile.

Table 11. *Stability Test for the Rise of Populist Movement Period (26/05/2014-31/12/2018)*

Market	*ATX*	*BEL 20*	*OMX H 25*	*CAC 40*	*DAX*	*ATHEX LC*	*ISEQ Overall*	*MIB*	*AEX*	*PSI 20*	*IBEX 35*
Distribution	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal
						Mean Statistics					
μ_{Euro}	4.1771E-02	3.3660E-02	4.2091E-02	2.4358E-02	3.4035E-02	3.8468E-02	4.2687E-02	4.4956E-02	3.2119E-02	4.1652E-02	4.2365E-02
	(2.336E-03)	(2.115E-03)	(2.471E-03)	(2.513E-03)	(2.669E-03)	(2.549E-03)	(2.965E-03)	(1.970E-03)	(2.252E-03)	(2.425E-03)	(2.239E-03)
μ_i	2.5922E-02	2.6019E-02	4.8286E-02	4.6757E-02	4.4106E-01	2.9950E-03	1.4756E-01	2.6007E+00	4.7916E-04	6.3112E-02	4.4258E-01
	(1.303E-03)	(1.539E-03)	(2.492E-03)	(4.438E-03)	(2.811E-02)	(1.485E-04)	(6.979E-03)	(9.871E-02)	(3.508E-05)	(2.745E-04)	(2.167E-02)
						Off Diagonal Co-Variance Statistics					
$A_{Euro, i}$	6.5956E-02	7.4354E-02	2.5277E-01	4.6829E-01	-1.3120E-01	1.4008E-02	2.4249E-01	3.7100E+00	6.3213E-04	1.3655E-01	2.2454E+00
	(1.296E-02)	(2.989E-02)	(2.878E-02)	(1.339E-01)	(5.078E-01)	(2.074E-02)	(6.206E-02)	(1.605E+00)	(7.406E-04)	(4.740E-02)	(3.840E-01)
$A_{i, Euro}$	7.0825E-02	2.2526E-01	-7.6780E-04	5.5285E-02	1.7186E-02	3.0693E-02	3.4760E-02	1.3161E-03	8.5865E+00	2.2882E-02	3.2391E-03
	(2.831E-02)	(4.011E-02)	(2.234E-02)	(2.971E-02)	(4.306E-03)	(8.795E-03)	(8.269E-03)	(4.971E-04)	(2.663E+00)	(4.679E-03)	(3.452E-03)
$B_{Euro, i}$	-9.8366E-02	9.6478E-02	-1.5693E-02	1.8777E+00	-6.7737E+00	-5.8065E-01	2.8419E-01	1.5017E+01	6.5862E-03	-3.1323E-01	-2.1523E+00
	(1.447E-02)	(5.499E-02)	(5.529E-02)	(2.663E-01)	(5.657E-01)	(3.171E-02)	(7.833E-02)	(3.471E+00)	(1.026E-03)	(6.020E-02)	(5.787E-01)
$B_{i, Euro}$	-6.3768E-02	-2.2701E-01	-2.7863E-01	-3.9242E-01	3.6006E-02	2.0875E-01	-9.7483E-03	-3.8105E-03	-1.8047E+01	2.3561E-02	2.4226E-03
	(3.200E-02)	(8.698E-02)	(4.425E-02)	(6.335E-02)	(4.649E-03)	(1.331E-02)	(1.236E-02)	(1.085E-03)	(3.638E+00)	(6.853E-03)	(4.240E-03)
$D_{Euro, i}$	2.0374E-01	-2.4470E-06	1.8480E-06	-2.9151E-05	-1.2676E-04	3.5310E-02	-6.2155E-02	-9.4102E+01	-9.0000E-08	1.0238E+00	-4.0354E-05
	(1.724E-01)	(2.238E-01)	(2.996E-01)	(8.773E-01)	(4.723E+00)	(1.635E-01)	(6.667E-01)	(1.271E+01)	(4.641E-03)	(5.597E-01)	(2.363E+00)
$D_{i, Euro}$	-8.8674E-01	-2.2260E-06	2.2700E-07	-1.0818E-05	-1.1050E-06	-3.9788E+00	-2.5844E-01	3.6774E-02	1.5700E-06	-4.8491E-02	-5.5900E-07
	(5.766E-01)	(4.216E-01)	(1.862E-01)	(2.247E-01)	(3.752E-02)	(6.380E+00)	(7.726E-02)	(4.498E-03)	(2.084E+01)	(1.372E-01)	(3.029E-02)
						Model Statistics					
Log-Likelihood	3,268.6108	3,351.5086	2,640.4200	3,063.0282	503.8979	1,736.1457	1,282.4553	-1,796.3557	8,207.2039	1,236.5167	304.3198
Final Criterion	7.50E-06	0.00E+00	5.20E-06	7.30E-06	5.00E-07	8.80E-06	2.70E-06	3.70E-06	0.00E+00	3.90E-06	7.10E-06
						Co-integration Volatility Test					
σ^2_{Euro}	0.208121										
σ^2_{Market}	0.118393	0.197020	0.184744	0.401641	1.976284	0.684980	1.194872	11.891184	0.003519	0.751496	2.286339

Stability Test ($Market_{Euro} \rightarrow Market_i$)											
Statistics	2.9548	2.3091	2.1999	2.3877	3.6968	1.8079	0.3946	6.3365	5.9958	0.1674	0.3704
Status	Volatile	Volatile	Volatile	Volatile	Volatile	Stable	Stable	Volatile	Volatile	Stable	Stable
Stability Test ($Market_{Euro} \leftarrow Market_i$)											
Statistics	6.7023	2.7898	3.6891	2.3721	0.4428	5.5952	0.9090	0.0801	63.1730	1.0969	0.4061
Status	Volatile	Volatile	Volatile	Volatile	Stable	Volatile	Stable	Stable	Volatile	Stable	Stable

Summary of the results

It is worth noting that theoretically in econometrics a fully integrated market news affecting one segment would affect all segments and hence the magnitude of the volatility spillover effect would be similar thru all segmentsas hinted by Baele (2005) and Bekaert *et al.* (2002). In reality the markets do react differently to news depending on the affinity of the market's participants to the event. In a market, such as the Eurozone, where there is a number of diverse factors influencing the behaviour of market participants in each segment; the reaction to news and thus magnitude of the volatility spillover effect is likely to differ between segments and thru time. The truth is that the impact of any event is connected to "time and space" and hence the gravitational pull of the reaction is determined by the close affiliation of the market participants to the event at any given time.

In analysing the complete picture, you get the impression the interaction between Eurozone equity markets is governed by the underlining context as illustrated by Table 12. Simply put, this means that the market environment is key to financial integration, hence market participants reaction to general market environmental factors determine the level and stability of the financial market integration. Furthermore, these environmental factors are influenced by the "time and space" effect. In essence, this means that market participants react differently to any news or event at any time given the market.

Table 12. *Statistical Ratios of Results*

Period	*Direction*	*Pre-Euro*	*Euro Introductory*	*Bull Market*	*Financial Crisis*	*Sovereign Debt Crisis*	*Populist Movement*
News Contagion	Euro → Market	8:2	5:6	3:8	8:3	8:3	7:4
	Euro ← Market	3:7	5:6	4:7	2:9	2:9	2:9
Volatility Spillover	Euro → Market	6:4	6:5	7:4	9:2	9:2	7:4
	Euro ← Market	4:6	4:7	5:6	4:7	5:6	5:6
Negative News	Euro → Market	7:3	6:5	3:8	2:9	5:6	7:4

Effect	Euro ← Market	2:8	5:6	4:7	4:7	4:7	8:3
SMPCH	Euro → Market	6:4	8:3	6:5	8:3	3:8	7:4
	Euro ← Market	7:3	9:2	5:6	10:1	8:3	6:5

As illustrated by Table 12, the behaviour of market participants varies depending on the market and event in time. Hence the general differences and similarities in reacting to varying events which is illustrated by the period of high uncertainties during the later part of the observation. There are several similarities and yet several differences in the reactions to the events during the financial and sovereign debt crises and populist movements period.

The funny thing is thateven though the Eurozone financial markets may react differently; yet in the overall scheme of things the evidence from the literature is that of integration, especially during the euro introductory and bull market periods. In truth the Eurozone equity markets were never truly integrated as dictated by the econometrics theories earlier in this section and illustrated by Table 12. However, this does not mean that the markets were never integrated in accordance to the definition of Baele *et al.* (2004).

Conclusion

In this paper, we extended the volatility test to analyse the stability status of the integration of the Eurozone equity markets in the aftermath of the Euro by introducing a multivariate volatility test. The underlining model was a bivariate asymmetrical BEKK GARCH, allowing us to analyse the volatility spillover, news contagion effect and stability of the market environment during six different periods with differing impacts.

Surprisingly, our findings seem to be hinting at generally news and volatility seem to travel from the Eurozone to the sovereign equity market. Conversely, the results of our stable market pre-condition hypothesis seem to suggest generally with the exception of two observed periods, the underlining market environment is stable. Unsurprisingly the two exceptions occur when the markets either massively underreact as in the case of the bull market period or massively overreact as in the sovereign debt crisis within the Eurozone.

Our empirical results point to differences in the reaction of market participants which hints at the "time and space" effect. This seem to be suggesting that the Eurozone equity markets were never truly integrated in the sense of the econometrics definition. However, this does not mean that the Eurozone equity markets were not integrated in accordance with the definition of Baele *et al.* (2004). What is without doubt is the reactions of market participants depends on two factors: the time and market of the eventas illustrated earlier, hence the "time and space" effect. This is what drives the Eurozone equity market's integration, especially during highly volatile and uncertain times.

A relevant factor raised by our empirical evidence regarding the stability of some markets during highly volatile periods is they seem to be defying conventional wisdom by being stable, in particular the Greek market during the sovereign debt crisis. As hinted by Fakhry (2016b), a possible explanation could be found in the underreaction / overreaction hypothesis which suggests that market participants' reaction leads to overvaluation or undervaluation during any period. Hence, a highly volatile period with instances of both under reaction and overreaction could give the impression of a stable market. This is what seems to have happened during these periods as market participants reacted to the information and news.

We also reviewed the literature on the integration of the Eurozone equity markets in the aftermath of the introduction of the Euro. We found most of the past empirical and literature pointed to an acceleration of the integration in the aftermath of the euro's introduction and during the bull market. However, this was slowed down in the aftermath of both crises; although, the literature does point to the sovereign debt crisis having a bigger impact than the financial crisis. Nevertheless, the real danger is in the rise of the populist and nationalist movements across Europe which depending on the views could result in the disintegration of the EU and thus the Eurozone. The case of Brexit and the resulting deal will no doubt be watched carefully with the potential of others to follow suit, there are already signs that the Italians want out.

A relevant factor to emerge from the Brexit and 2014 European Union parliamentary elections is that many people don't fully understand the workings and fundamental concept of the European Union. Hence, many on the opposing view are able to significantly highlight the weaknesses of the European Union. This points to a lack of communication by the European Union parliament. We therefore advise the European Union parliament to communicate more with the population in order to raise the awareness of the work and concept of the European Union. Another issue raised was the loss of a sense of national identity, therefore pushing a significant number to extreme nationalist. Although, I am a supporter of European integration; however, a policy of slower paced integration would be of benefit to most considering the rise in nationalist views within the European Union and Eurozone. A key issue raised by the recent crises is the miscommunication and disjointed actions by key politicians which resulted in the financial markets being highly volatile and over reactive. We recommend the setup of a committee to oversee the communication and actions, especially during any future crisis, which would help to stabilize the Eurozone financial markets and therefore lead to a more integrated financial market.

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