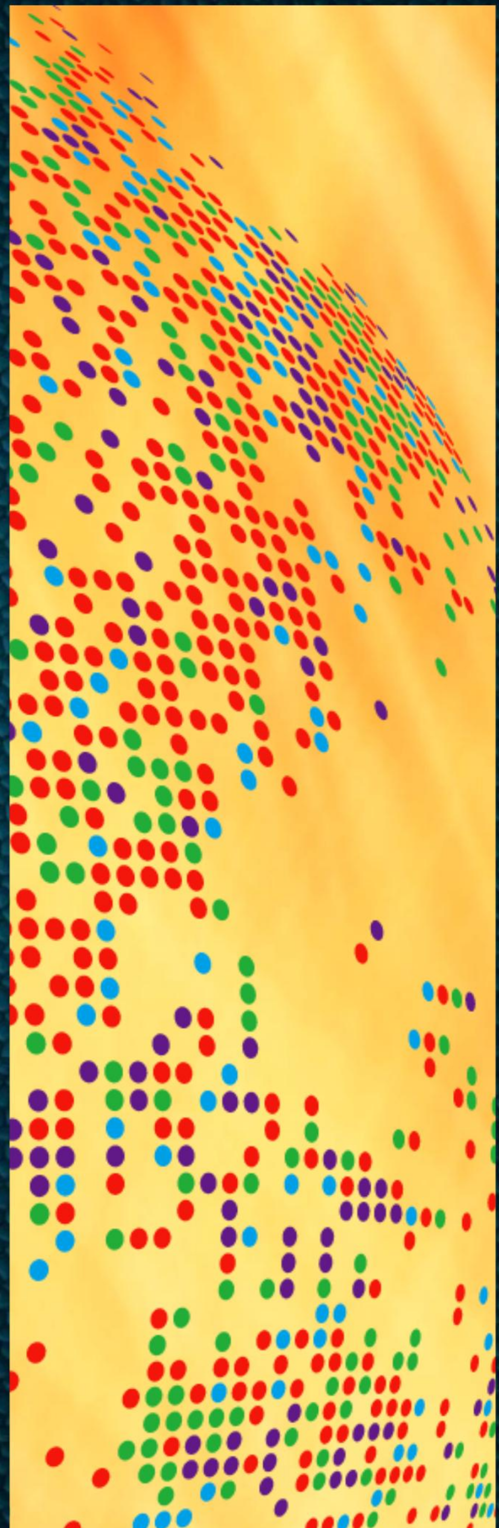
Studies on the Sovereign Debt Market



By

Bachar Fakhry

Christian R. Richter

KSP Books

Studies on the Sovereign Debt Market

Bachar Fakhry
University of Lahore, Pakistan
Christian R. Richter
German University in Cairo, Egypt

KSP Books
http://books.ksplibrary.org
http://www.ksplibrary.org

Studies on the Sovereign Debt Market

Bachar Fakhry
Christian R. Richter

KSP Books
http://books.ksplibrary.org
http://www.ksplibrary.org

ISBN: 978-605-7736-92-5 (e-Book)
KSP Books 2020

Studies on the Sovereign Debt Market

Author: ***Bachar Fakhry*** [a] ***& Christian R. Richter*** [b]

[a] University of Lahore, School of Accountancy & Finance, Lahore, Pakistan.

[b] German University in Cairo, Faculty of Management Technology, Egypt.

http://books.ksplibrary.org
http://www.ksplibrary.org

Preface

The Sovereign Debt Market is an essential section of the global financial market. In essence it is the main route for governments to cover any fiscal deficit in their budget. As of end of 2018, the market was US$188 trillion according to the IMF report on 17 December 2019. The market was long regarded as a safe haven for investors, especially the US treasuries and German Bunds. However in recent years the market has suffered several crises leaving investors questioning their high quality ratings. In this book we look at the efficiency and stability of the sovereign debt markets at the heart of the crises: US, German, Greek, Italian Portuguese and Spanish sovereign debt markets. We ask ourselves are these markets moving according to the Efficient Market Hypothesis or Behavioural Finance Theory?

i. *Is the sovereign debt market efficient? Evidence from the US and German sovereign debt markets*

   This chapter analyses the efficient market hypothesis. It proposes a new method of testing the efficient market hypothesis based on the idea of (Shiller, 1979). Using a GARCH model, we test whether the excess volatility in the German and US sovereign debt markets is an indication of in efficient markets during different periods. The results indicate that omitting structural breaks may lead to wrong results. We find that although both debts were efficient during some periods and inefficient during other periods of time. Taking all periods together the financial markets appear to be inefficient. Hence, the general outcome was that both financial markets are not efficient markets.

ii. *Testing the Efficiency of the Sovereign Debt Market using an Asymmetrical Volatility Test*

We test the efficiency of the financial market using the daily prices of the US and German sovereign debts between July 1, 2002 and December 31, 2011. This allowed us to test the efficiency during the pre-crisis, financial and sovereign debt crises periods. We extend the variance bound test of Fakhry & Richter (2015) using a GJR-GARCH model. This hints at our contribution, i.e., the inclusion of the asymmetrical effect in the variance bound test. Our tests produced mixed results, pointing at the markets being too volatile to be efficient. Interestingly, the addition of the asymmetrical effect led to a reduction in the EMH test statistics based on the results from Fakhry & Richter (2015) and hence may have had an impact on the efficiency of the market. Conversely, this is more appropriate to speak of bounded rationality than irrationality. A key conclusion of the paper is it hints at the use of a switching GARCH model as an alternative to the GJR-GARCH. Therefore, a prospective future research could be the use of a switching GARCH model to analyse the different impact of high and low volatility regimes on market. Given our key conclusions, another prospective is the use of sovereign debt indices instead of the issued sovereign debts.

iii. *Testing the Efficiency of the GIPS Sovereign Debt Markets using an Asymmetrical Volatility Test*

The efficient market hypothesis has been around since 1962, the theory is based on a simple rule, namely that the price of any asset must fully reflect all available information. Yet there is empirical evidence financial markets are too volatile to be efficient. The empirical evidence suggests that the reaction to events is the crucial factor, rather than the actual information. Generally, market participants react differently to negative and positive market shocks, hinting at asymmetrical effects. This paperanalyses the impact of asymmetrical effects on the efficiency of the financial market during the recent crises. We test the efficiency of the financial markets using the daily prices of the GIPS sovereign debts between June 2007 and December 2011. This allowed us to test the efficiency during the financial crisis and sovereign debt crisis periods. We used a GJR-GARCH based variance bound test based on the test derived by Fakhry & Richter (2015). Our tests provide evidence forfinancial markets being too volatile to be efficient. At the same time, the results are pointing towards bounded rationality rather than irrationality.

iv. *Does the Federal Constitutional Court Ruling Mean the German Financial Market is Efficient?*

Following the landmark ruling by the German Federal Constitutional Court in Karlsruhe on 7th February 2014 in which they endorsed the efficient market hypothesis, we present evidence on the efficiency of the German financial market. Introducing a new variance bound test based on the Component-GARCH model of volatility to analyse the long- and short-runs effects on the efficiency of the German financial market, we test the price volatility of three markets: DAX stock index, German sovereign debt index as provided by Barclays and Bloomberg, Euro gold index by the World Gold Council and Euro currency index by the Bank of England. The results seem to be indicating a relatively strong acceptance of the efficient market hypothesis in both the short and long runs in all the observed financial markets.

B. Fakhry & C. Richter
March 17, 2020

Acknowledgements

We would like to thank our families and friends for their patient and understanding during the writing of the content of this book. We would also like to thank the editors of the journals for the time and efforts in publishing the papers which makes up the book. Finally we would like to dedicate this book in memory of Mr Richter, Professor Christian Richter's father, and Professor Hughes-Hallett.

Contents

Chapter 2

Testing the efficiency of the sovereign debt market using an asymmetrical volatility test 43

Chapter 3

Testing the efficiency of the GIPS sovereign debt markets using an asymmetrical volatility test 66

Chapter 4

Does the federal constitutional court ruling mean the German financial market is efficient? 89

Introduction

The financial crisis and ensuing economic downturn and sovereign debt crisis have bought a heated debate about which policy to implement during a long and deep economic downturn. Both countercyclical monetary and fiscal policies have their benefits and costs. The debate is between inflationary pressures see (Rudebusch, 2010) or high taxes see (Tobin, 1971). The other issue is that lags in the implementation of any fiscal stimulus policy may have a delayed and hence adverse effect on the economy see (Friedman, 1948). However, as hinted by Feldstein (2009) and Taylor (2008) it seems that there is a need for both policies in the current climax. In this section of the book, we critically review the theory and evidence for both stimulus policies.

The macroeconomic arguments influencing the monetary policy

In a way, as Bernanke & Reinhart (2004) state the function of monetary policy is to influence the prices and yields of financial assets, thereby affecting the economic decisions and hence the direction of the economy. Moreover, as Clarida *et al.* (1999), Romer & Romer (1989) and Bernanke & Mihov (1996) state that monetary policy influences the economy in the short term.

According to Friedman (1982), a monetary policy targeting full employment or economic growth is not feasible. Furthermore, as Barro & Gordon (1983) argue there is no changing relationship between monetary policy and employment. Additionally, as Friedman (1968) states many would suggest that the role of monetary policy is to keep interest rates low in order to offset the interest payment on sovereign debt in an alternative fiscal policy solution. However, as illustrated by many episodes of high inflationary pressures holding interest rates low, i.e. cheap money, could be counterproductive.

Friedman (1968) advocated the used of an aggregate money supply target to control the economy and asset prices. This means in times of an economic upturn there would be a decrease in money supply and in times of an economic downturn, there would be an increase. There is the option of alternating between policies of inflation rate targeting thru the use of interest rate and aggregate money supply targeting by altering money supply as suggested by Bernanke & Reinhart (2004). Moreover as argued by Bernanke & Reinhart (2004), a key question is what happens when the short-term interest rate is approximating or at zero. According to Bernanke & Reinhart (2004), there are a number of options open to the central bank:

- Since the prices of many financial assets depend on the expected short-term interest rate in the long run, a possible option is to influence the market participants short to medium term expectation on the short-term interest rate. This could be either unconditional or conditional on a set of economic factors.

- Another option is to change the composition of its balance sheet. In essence, this involves either selling and buying short//long or selling and buying different assets e.g. selling sovereign debt in favour of stocks or other bonds. This would have the same effect of changing the supply/demand curve and hence the equilibrium price.
- Another alternative is to embark on a policy of quantitative easing or increasing money supply by expanding the balance sheet. In essence, this would mean the central bank buying financial assets from commercial banks, thereby reducing the risk factors and increasing the money in the economy. A key condition of this policy is that the overnight rate is zero.

However, as argued by both Leeper & Roush (2003) and Woodford (2007), there is limited evidence to suggest a relationship between inflation and money supply. In fact, the evidence seems to be suggesting an increase in money supply leads to an increase in the rate of inflation in the long run. Additionally, as Clarida *et al.* (1999) states the optimal monetary policy is to target an optimal inflation rate by adjusting the nominal rate, thus altering the real rate.

As stated by Leeper & Roush (2003), many central banks (i.e. Bank of England and more importantly in the context of this research the European Central Bank and Federal Reserves[1]) have opted to a long run policy of inflation rate targeting thru the use of interest rates. The problem with this policy is which price index to use and at what level should the target be set. As Bernanke & Mishkin (1997), hints the index needs to allow for shocks or a one-time shift in the short run without affecting the long run trend. A major issue

[1] The Maastricht Treaty mandates price stability as the primary objective of the European Central Bank. The Economic Growth and Price Stability Act of 1995 require that the Federal Reserve maintain price stability.

as pointed by Bernanke & Mishkin (1997) is that setting, inflation rate targets too low, i.e. close to zero, could cause unanticipated deflation, which can creates major problems to the financial system and inevitably economic contraction. A case in point is Japan.

Bernanke & Gertler (1999) suggest that since monetary policy has been relatively successful in the fight against inflation, it is likely that the next issue facing monetary policy will be a different target. They argue that evident from a number of industrialised nations seem to be pointing at increased volatility in asset prices that is instrumental in stock and real estate bubbles. Therefore, by tuning monetary policies to respond to asset price volatility, central bankers could reduce the threat of a bubble. The key word here, being 'reduce' because, while monetary policy is a key element, it is not the only required element in the elimination of the asset price bubble. They discuss several methods open for policymakers to use in controlling asset price bubbles. In concluding, they hint at a lack of desirability in responding to asset prices instead suggesting a flexible inflation-targeting policy.

Tobin (1983) states that the monetary policy of one nation could influence financial markets and instruments, i.e. interest and foreign exchange rates, of the other nations. In short as Tobin (1983) states the interdependent of the global economies and financial markets means a coordination of monetary policies. In other words as Tobin (1983, p.16) referring to the European Community, Japan and the US says:

> "None of the three locomotives can claim it is too small to influence the world economy"

Benigno & Benigno (2006) also argue this point and Devereux & Sutherland (2007) who agree an integrated globalise economy makes it hard for any country to be mutual exclusive in monetary policy. Devereux &

Sutherland (2007) also argue that due to the integration of financial markets and the diverse nation of market participants' portfolios, there is a need for monetary policy to control for inflation and foreign exchange rates, continuing that the optimal policy should be asset price stability using inflation targeting. This argument was the basis for Taylor (2009a) suggestingto introduction of global inflation reference target to eliminate the adverse effect of onecountry's policyon others

Many articles have documented the recent financial and sovereign debt crises [2] leading to the global economic recession. In the aftermath of these crises, monetary policy had to adapt to a fast changing and challenging environment. Here we will review the literature on monetary policy during the crises and economic downturn.

As highlighted by Blanchard *et al.* (2010), in the advent of the crises two key factors challenged the long held views. The first factor is that stable inflation is necessary but not by itself sufficient. Some have argued that the theory is too limiting and does not incorporate the increases in house prices. However, the problem is that no single inflation index could account for the movement in prices. Another issue is that both the combined stability of inflation and output could lead to misrepresentation of the undesirable behaviour of asset prices and credit aggregates. The second factor is that settinginflation too low leads to deflationary pressures or deteriorating fiscal positions.

As Bernanke (2009) hints aggressive reduction of interest rates is the first course of action available during a financial

[2] Financial crisis (Brunnermeier, 2009; Chari *et al.,* 2008; Gorton, 2008; Grosse, 2010).
Sovereign debt crisis (Blundell-Wignall & Slovik, 2011; Caceres *et al.,* 2010).

crisis for any central bank. However, as Bernanke (2009) states another key role of the central bank is to act as the lender of last resort to financial institution. This means the provision of liquidity in the shape of short-term loans for financial institutions i.e. commercial banks and primary brokers such as investment banks.

In many ways the provision of liquidity had mixed results, as Bernanke (2009) states on the one hand it does reduced the stress of short-term liquidity and increase the ability for these financial institutions to lend and operate in the market. However, as hinted by Bernanke (2009), as was obvious during the financial crisis and to a certain extent the sovereign debt crisis, this does not solve the problems in certain markets such as the commercial paper and asset backed loans. The problem with the asset backed loan market was the loss of confidence in the quality of the assets held by these financial institutions. So many central banks gave short-term loans against commercial papers and triple A rated asset backed securities in an attempt to provide liquidity to these markets according to Bernanke (2009).

However, as Mishkin (2009) says many have argued that monetary policy has been ineffective during the financial crisis and similarly to a certain extent the sovereign debt crisis. In addition, Mishkin (2009) hints that the majority of these arguments could be broken into two conclusions: credit easing has failed and hence monetary policy is ineffective, so there is no reason to continue with it. The second conclusion is easing monetary policy could lead to inflationary pressures. Contrary to this view, Mishkin (2009) argues that aggressively relaxing monetary policy by cutting interest rates have helped reduced credit and macroeconomic risks. The key thing is that it had kept interest rates on default-free bonds such as Treasuries lower. In providing liquidity to the financial markets, the central banks have reduced the inability of the markets to perform.

In essence, as stated by Mishkin (2009), controlling inflation is down to controlling the expectation of the markets and public about future inflation. The key here is clear communication about the monetary policy and the reputation of the central bank in controlling inflation.

Taylor (2009a) argues the key issues with the policies were firstly that a deviation from the standard and largely successful monetary policy meant that interest rates were too low for too long which caused the bubble. Secondly, a misdiagnosis of the problem early in the crisis meant for the policy makers, providing liquidity took priority over focusing on the root of the problem, which was a rise in risks. The third problem was the ununiformed action of providing assistance to one some and none to other financial institutions.

Friedman (1968) warned against fixing nominal interest rate when inflation was moving, as it would cause instability. Since as Blinder (2010) states effectively there was a fixed zero nominal interest rate, thus meaning a drop in inflation will lead to a rise in real interest rates causing deflationary pressures. This generally leads to a downwards-trending economy with weak aggregate demand. The problem is that once nominal interest rate hit the zero lower bound, *"conventional monetary policy is out of bullets"* as Blinder (2010, p.466) puts it. Therefore, as is the case with the ECB and Federal Reserve, the central banks started using unconventional monetary policy including quantitative easing.

According to Blinder (2010), quantitative easing works thru two channels, either by flattening the yield curve or reducing risks/increasing liquidity. And as Blinder (2010) states there two methods of operating a quantitative easing policy: the first method is thru changing the composition of the balance sheet from "riskless" or short to risky or long securities. The second is to increase money supply and buy securities therefore enlarging the balance sheet.

As stated by Krishnamurthy *et al.* (2011), the idea behind flattening the yield curve is to sell short term in favour of long-term securities. Thus flattening the yield curve and reducing the long-term interest rates, in the hope of stimulating economic activity. As highlighted by Krishnamurthy *et al.* (2011), the evidence does point to a reduction in the medium to long-term interest rates. In contrast to the evidence of small impact on risky assets of the purchasing of only Treasuries and agency bonds as hinted by Krishnamurthy *et al.* (2011). However, there is strong evidence that the purchase of risky or illiquid assets does have a positive impact on the rates of these assets.

As Rudebusch (2010) states an issue for any central bank, regarding these unconventional monetary tools is the exit strategy. One key factor in the decision is that these tools could lead to high inflationary pressures, however a counter argument is that exiting too quickly could lead to big issues concerning the economy and financial market. A case in point is quantitative easing where exiting the policy too quickly could lead to an increase in supply and hence to a high downwards pressures on the assets prices. As highlighted by Rudebusch (2010) there is little historical empirical evidence on the effect of the timing and magnitude of selling the securities. In fact, as will become clear in the next paragraph, there is recent evidence from the Japanese economy and financial market on the effect of unconventional stimulus monetary policies. The case of Japan seems to suggest deflationary pressures are just as likely.

In order to assess the likely impact of the current use of unconventional monetary policies on the economy and financial markets, it is essential to understand the experience of Japan's monetary policy of the late 1990s-early 2000s. As

Shiratsuka (2010) argues, there are similarities between the actions of the Bank of Japan in the late 1990s-early 2000s and the major central banks responses throughout the recent crises and economic downturns. In order to ease the pressures of liquidity and credit, the Bank of Japan changed its main monetary policy to targeting a level of outstanding balance of the current account balances, which was originally set to 5 trillion yen, and eventually rising to 30-35 trillion yens. Due to the deflationary pressures, until the inflation rate stabilised and above zero, the Bank of Japan was committed to this policy. Initially the Bank of Japan concentrated on the long term Japanese government bonds, in the later stages of the policy they diversified to asset-backed securities.

Since, as stated by Shiratsuka (2010), the evidence suggests monetary expansion had little effect on output and inflation in the case of Japan and given that our research is essentially on the behaviour of financial markets. This means that we will concentrate on the impact of the Bank of Japan policy on the Japanese financial markets. The policy and commitment led to the restoration of liquidity in the markets, therefore stabilizing the financial sector. However, the positive impact from the quantitative easing policy did not transfer to the wider non-financial commercial sector suggesting that the policy did not have a strong impact on the deflation expectation of the financial markets. Another big issue is due to the Bank of Japan lending schemes, which were at very low interest rates, the financial institutions became reliance on these schemes and hence the money markets were unable to recover. In the end, the key to the success of the policy was the clear communication and commitment by the Bank of Japan as hinted by Shiratsuka (2010).

The macroeconomics argument influencing the fiscal Policy

At the heart of the argument on whether or not to use a fiscal stimulus policy are two related basic issues. The issues are the costs and impact of any such fiscal stimulus policy on the economy. A key factor is, as highlighted by the recent use of fiscal stimulus policies, they can be very expensive and hence adding to the already high debt levels of most countries. As Tobin (1971, p. 91) states

> "How is it possible that society can merely by the device of incurring debt to itself can deceive itself into believing that it is wealthier? Do not the additional taxes which are necessary to carry the interest charges reduce the value of other components of private wealth?"

Hence, in the medium to long term the burden of the debt on the economy is likely to be high either, leading to a reduction in the fiscal expenditure or an increase in the tax levels in the longrun and in some cases both. A point illustrated byAuerbach (2003) who argues past experiences hints at increases in tax and/or decreases in expenditure whenever there is a large increase in expenditure leading to a budget deficit. However, as Keynes (1923) argues

> "The long run is a misleading guide to current affairs. In the long run we are all dead. Economists set themselves too easy, too useless a task if in tempestuous seasons they can only tell us that when the storm is past the ocean is flat again."

However, as Auerbach (2003) hints that any fiscal stimulus would have to take into account the huge debt and cost of servicing that debt. The problem is as Mydral (1939) states during a depression all types of fiscal revenue decrease even without a reduction in the tax rates while the fiscal expenditure increases holding welfare expenditure stable. Hence, as Mydral (1939, p.183) highlights

> "with few exceptions, a budget is never, and never has been balanced in a depression"

Mydral (1939) states that the optimal fiscal policy depends on the state of the economy, whether it is in a temporal setback or a prolonged stagnation. In essence, a stagnating economy, as in the case of the US in the 1930s, hints at specific adjustment issues in the structure of the economy. The problem is most fiscal stimulus policies do not attack the fundamental root causes of the large adjustment problems. Hence, in such situations the optimal fiscal policy is the one that patiently reforms the deep causes of the adjustment problems. As Magud (2008) argues, the initial economic condition at the time of the shock based on the fiscal status of the government should determine the fiscal policy response to the economic downturn.

As Magud (2008) explains the classical fiscal policy, approach to an economic downturn implies the reduction of government fiscal deficit by a decrease in expenditure. Therefore, reducing demand for credit and hence the interest rates, this should have the effect of rising demand for investments and consequently the economy pulls out of a recession via the private sector. In contrast, Keynesian fiscal policy dictates that the government should response by raising expenditure to boost aggregate demand and hence output improving employment. As put by Keynes (1936) since the level of output and employment are determined by aggregate demand, hence in an economic downturn the government need to stimulate demand to improve the economy.

However, Friedman (1948) proposed that a fiscal policy should be fixed and based on a stable and progressive personal taxation system whereby government expenditure on goods and services would not change unless the perspective of the "community" changes. Moreover, Friedman states that changes in the tax system should reflect the changing "community" perspective on the levels of expenditure on goods and services.

Friedman (1948) argued against fluctuating the fiscal policy with the business cycle, stating that lags would make the stimulus too late to have any real impact. A point also argued by Blanchard *et al.* (2010) who state that lags in the fiscal policy meant that in general the impact of a stimulus policy on the economy was too late due to most recessions being too short. Remember, many recessions since the late 1980s have lasted only two or three quarters in many advanced countries, the obvious exception was Japan. As Blanchard *et al.* (2010) hint the prevailing view in many advanced economies was the reduction of sovereign debt to more sustainable and stable levels. And as Blanchard *et al.* (2010) state many were sceptical about the effect of fiscal policy and the general view was that monetary policy provided stable output gap, hence there was little reason to use another policy. Therefore, as Blanchard *et al.* (2010) indicate the main fiscal policy response to a shock to output was the automatic stabilisers, which kicked in whenever the economy showed signs of a downturn, as these policies did not affect the sustainability and stability of the debts.

Auerbach (2002) hints at uncertainty regarding the size of the impact from a fiscal stimulus policy on the output. He states that there is little evidence to suggest a fiscal stimulus policy would have a stabilizing impact on the economy. Also suggests contractionary fiscal policy may have a bigger positive impact on output.

In order to understand the general factors influencing the current arguments, there is a need to review the current literature. As was highlighted by Blanchard *et al.*, (2010) and Auerbach (2002) not so long ago the consensus was that fiscal stimulus policies did not work mainly due to the large impact on the debt and the lagged effect and hence countercyclical monetary policy was the way forward during economic downturns. However, as highlighted by Blanchard *et al.* (2010) the basis of this view the factors that are redundant in the 2008/2009 environment. Previously stated by Magud (2008) the fiscal policy response should be determined by the economic condition at the time and the fiscal statistics.

As Taylor (2000) hints in the 1980s and 1990s, the emphasis was on using the automatic stabilizers as the tool of choice for fiscal stimulus policy. Mainly, because the economic environment did not need a full stimulus policy, but also because of advances in monetary policy rendering such policies and their huge expenditure redundant. However, as Taylor (2009) states this view has changed amongst academics and policy makers alike in the aftermath of the financial crisis, which led to the deepest recession since the 1930s. He highlights the success of the rebate policy of 2001 and 2008 in overcoming the fiscal stimulus policy lag problems. Nevertheless, he concludes that there is no rationality for the revival of fiscal stimulus policies.

Although Feldstein (2002a) agrees that there is little evidence of fiscal stimulus policies having a positive impact on the economy, yet he argues there is one strong area where the use of fiscal stimulus policies could have a positive impact on the economy. A long and sustained economic downturn where interest rates, inflation and aggregate demand are low or falling; examples are the Japanese economy of the 1990s to early 2000s and the US economy during the great depression of the 1930s. A key argument against the use of fiscal stimulus policies is that they increase the budget deficit and thus lead to a higher total debt; however, as Feldstein (2002a) notes a fiscal stimulus policy need not raise budget expenditure. If the policy aimsat, providing increased incentives to spend then it could increase economic activity, therefore reducing the fiscal deficit.

Feldstein (2009) argues contrary to popular beliefs the evidence suggests that the massive stimulus programs of the 1930s did not do as well as some believe. Unemployment remained high until the outbreak of World War 2, so it was war that finally brought unemployment under control. Yet the pursuit of active fiscal policy in the form of Keynesian economics remained even after the war, leading to increasingly volatile cyclical economics. This led to high inflation and unemployment throughout the 1960s and 1970s.

Hence as stated by Feldstein (2009), in the 1980s counter cyclical policy shifted to the use of monetary policy instead, this resulted in a stable economy where both inflation and unemployment were relatively low and stable. Generally, during this period economic downturns were the results of monetary policy attempting to reduce inflation by raising interest rates for the short run. The reversal of this monetary policy tightening took place when inflation was under control, which meant that consumers were able to take advantage of the interest rates and more importantly expenditure increased.

As Feldstein (2009) highlights the difference is that the current economic downturn was caused by the massive under-pricing of risks and excessive leverage by the banks because of the low interest rates. Consequently, the financial crisis forced the banks into a re-pricing of risk and deleveraging which caused the credit markets to freeze. The problem is that most householders/consumers are reliant on the credit markets to offset their expenditure when this froze consumer expenditure collapsed. Feldstein (2009) estimated the loss on the economy of the reduction in consumer expenditure to be $400billion per year resulting in an economic downwards spiral. This led to a sharp decrease in house and share prices, which eroded the householder wealth to the tune of $10trillion as estimated by Feldstein (2009).

Both Taylor (2008) and Feldstein (2009) states given the economic environment, it is hard not to see why many are considering a second fiscal stimulus. Since the economic downturns lasted 18 months, from December 2007 to June 2009 and interest were and still predicted to remain low, previous issues with fiscal stimulus such as the policy lags and high interest rates did not impede. However, Taylor (2008) argues given the increase in debt it is natural for householders to think there will be tax increases in the medium to long run.

However, as Taylor (2008) argues there is a requirement to analyse the first stimulus in order to learn about the options for the second stimulus. As both Feldstein (2009) and Taylor (2008) argue, the evident shows the temporary rebate plan of the Economic Stimulus Act of 2008 did not have the desired impact on personal expenditure. Taylor (2008) states this was not surprising since the permanent income theory of Friedman dictates that temporary increases in income will lead to only small temporary changes in consumption. In short, limited period income will not lead to an economic recovery and will lead to a long-term increase in the debt. Another lesson highlighted by Taylor (2008) is do not aim the stimulus at a particular group and increase taxation on business and investments. In an economic downturn where two factors threaten householders, a reduction in their lifelong savings and unemployment, the last thing they need is increase taxes, which might put their jobs on the lines or further reduce their investments. Taylor (2008) argues the key weakness underpinning most stimulus policies and indeed most policymakers' statements is the lack of predictability and agreement to a stable plans ensuring that the financial markets remain unstable and householders and firms cannot properly plan. In essence, both Feldstein (2009) and Taylor (2008) argue against short-run stimulus policies, which do not stabilize the economy and leads to massive debt with little impact on the economy.

Both Feldstein (2009) and Taylor (2008) argue a permanent tax cut and indefinite postponement of tax rises on wealth, dividends and capital gains is likely to help. Feldstein (2009) also argues that under the current climax of high youth unemployment and low demand, the defence budget should not be decreased, the defence sector is key in maintain output and providing young unemployed with the skills to use when the economy recovers. As Feldstein (2009) states evidence suggests that research and development by business and academia will likely lead to new opportunities for the economy, hence he argues against cut in research funds and for investments tax credits. Essentially, both Feldstein (2009) and Taylor (2008) argue since there is an obvious agreement for a fiscal stimulus policy, it is of paramount important that the policy is aimed at permanent long run solutions that will stabilize both the financial markets and economy.

Aizenman & Pasricha (2010) found that although the federal stimulus expenditure was high but the evidence seems to suggest the collapse in the local and state budgets neglected the impact of the stimulus. This was mainly due to the big reductions in tax revenue and limited borrowing capabilities of the states. The problem is there are many issues regarding any new stimulus policy concerning both public and economists alike. The main issues as highlighted by Aizenman & Pasricha (2010) are:

- the lagged effect which could lead to inflationary pressures in the long run,
- the high debt/GDP ratio which could be a signal for higher taxation or/and a reduction in the federal expenditure in the long run,

- the moral hazard issue of rewarding states that are less prudent, especially in the case of the US,

However, as in the recent case of Valencia in Spain, this is not limited to the US.

Although there is an obvious, lack of literature on the impact of the recent US Fiscal Cliff and Debt Celling crisis episodes on the financial markets. Yet it is vital to understand the impact of the fiscal cliff on the global financial market. To put things in to perspective, the US sovereign debt market is by far the largest single financial market with an estimated $16.7 trillion as of end 2013 according to the Federal Reserve Bank of St Louis. The world's biggest financial institutions and sovereign wealth funds regard the US sovereign debt market as the risk free liquid benchmark financial asset in many of their portfolios. Bearing this in mind, a default by the US Federal government would probably lead to a financial crisis on a scale many times larger than the recent financial and Eurozone sovereign debt crises. However, the key question is would any of the two main parties, the Republican or Democrats, haverisked the dangerous consequences of a global financial system meltdown and deeper global recession just when the global economy was struggling to recover from the deepest recession since the 1930s? The answer lays in the deadline agreement on each occasion with both sides making concessions. Another key question is how did both crises affect the global economy and financial markets in both the short term and long term?

One could look at the previous default by the US for clues; in 1979, the US defaulted on interest payments, which resulted in a hike on interests for US Federal debts and inevitably US households' debts and firms' debts. However, the impact on the global economy and financial markets were limited. The problem is, as explained earlier, the integrated global financial sector of today is different from

1979 and many global financial institutions regard the US reasuries market as the risk fee liquid market. The answer may lay in the reaction of the market to the Greek sovereign debt crisis. However, if the US does default it will be a technical default on a single interest payment. This however will be enough to signal a single downgrade in the credit rating of the US Treasuries as hinted by the credit rating agencies.

In order, to understand the effect of the economic downturn and sovereign debt crisis on the Eurozone, there is a need to understand the effect of monetary union on the monetary and more importantly fiscal policies. As highlighted by Gali & Perotti (2003), the main criticism of the Maastricht Treaty and the Stability and Growth Pact is the constraints they put on the fiscal policy of member states of the Eurozone with ratios of 3% deficit and 60% debt to GDP. The argument is during an economic downturn, the member states cannot use a fiscal stimulus policy to ease the pressure because of the limits on the deficits put by the Stability and Growth Pact. As a result, the Stability and Growth Pact could work against the countries, in an economic downturn, due to the procyclical effect on the economy. This means that instead of increasing expenditure to assist in a fiscal stimulus policy, the countries may have to tighten fiscal policy making the downturn worse because they have lost control of monetary policy. The criticism that the Stability and Growth Pact in some countries has impaired the ability to provide an adequate level of services and infrastructure extends this argument.

At the time, Gali & Perotti (2003) did not find much evidence in support of these arguments. In contrast, they find evidence of increasing counter-cyclical policy, although not at the level of some other industrialized nations. While public investments in services and infrastructure have steadily decreased over the years but that is not limited to the Eurozone countries, they find evidence of reductions in public investments in other industrialized countries. They conclude one reason for their findings is that since the initiation of the EMU, real recessions have been rare amongst the member countries. Hence, the empirical evidence may not have tested the constraints implied by the Stability and Growth Pact.

However, the current environment changed that perspective. The already large debts in some countries, while in some countries an economy that has been on a downward trend for a long time before the financial crisis. The fiscal stimulus policies only served to worsen the fragile economy in those countries and led to a complete imbalance between the revenue and expenditure with unemployment rising. This led to the sovereign debt crisis as markets lost trust in the fiscal policy of most of these countries in the aftermath of the Greece upwards revival of their fiscal deficit. This along with the inability of the Eurozone leadership to come to a unified agreement on how to solve the economic crisis underpinning the sovereign debt crisis led to the deepening of the crisis. The other problem is as highlighted earlier by Taylor (2009b) is miscommunication, as hinted by Carmassi & Micossi (2010). The problems were amplified by the display of confusion among the European Community and often conflicting statements by politicians.

A key issue in any financial market is as Keynes (1932) states since the markets require a diverse range of government debts of various maturities and types, it would be possible for the government to minimize the cost of debt by supplying heterogeneous debts. This is especially so during a financial crisis where flights to quality, liquidity or safety are in action. However, Mydral (1939) hints some governments attempt to conceal budgets deficits and thus present a "balanced" budget, this leads to asymmetrical information during economic upturns as well as downturns.

This could lead to a lack of trust by the financial markets in the governmental statistics as in the case of Greece recently.

Concluding review

In concluding, as will be illustrated in section 4.2 and by many such as Feldstein (2009) and Taylor (2008, 2009b), the financial crisis and ensuing economic downturn left the global economy in such a state that conventional countercyclical monetary policy on its own was never going to be enough. However, neither were any conventional fiscal automatic stabilizers enough to tackle the economic issues as illustrated by Feldstein (2009) and Taylor (2008, 2009b). This highlighted an argument between proponents of unconventional monetary and fiscal stimulus policies. In truth, the debate was about whether using any unconventional policy to stimulate the economy in the short run would outweigh the costs of implementing such policies in the long run. The other debate was whether to use unconventional fiscal policies or unconventional monetary policy.

It is essential to note, as highlighted earlier in this section, that long before the turn of the century monetary policy in both the Eurozone member states and the US have been successful in controlling inflation and keeping the economy growing as hinted by Bernanke & Gertler (1999) and Taylor (2009a). Therefore, many academics, economists and policy makers saw little need for stimulus policies, especially fiscal as highlighted by Auerbach (2002) and Blanchard *et al.* (2010).

In essence, such was the state of the economy that both policies were used in the early stages in some countries such as the US and UK. And in the absent of monetary policy to stabilize their economy, contrary to the stated constraints of the Stability and Growth Pact, many Eurozone member states implemented unconventional fiscal stimulus policies.

As will be illustrated by section 4.2, these policies resulted in high debt/deficit to GDP ratios and highly inflated central banks' balance sheets with very low interest rates. However, though these statistics could contribute to a huge share of the problems in the sovereign debt markets, it is fair to say that asymmetrical information and the ensuing lack of trust was at the heart of the initiation of the sovereign debt crisis as in the case of the Greek crisis. On top of that, there was a generallack of agreement between the different parties on how to solve the crisis as in the Eurozone sovereign debt crisis and the US fiscal cliff crisis. The problem as indicated by the fall in prices to below the par values of the sovereign debts from the GIPS group of nations over the past few years and recently the US, is this crisis hits demand.

In many way, the issue today is that how to scale back the stimulus policies without hurting the economy. With respect to monetary policy, the problem is the longer the unconventional monetary policy is still in use the higher the chance of inflationary pressures in the long term. However, in contrast, the quicker the reduction in central bank's balance sheet, the more likely, that the market will become over supplied which will hit the asset prices leading to a liquidity trap. The concern for monetary policy makers is how to unwind the quantitative easing policy without leading to inflationary pressures and downwards pressures on the asset prices. The problems faced by the fiscal policy makers are similarly tough; the choice is between higher taxes or lower expenditure, get the balance wrong and the economy could be in a bad state for the long run.

In concluding, the issue at the heart of this hot debate remains unresolved that is how to stimulate an economy, which had just faced a big financial crisis leading to a huge economic downturn. There is a hint of catch 22 about this in that as Tobin (1971) hints in the long run there are issues with both policies one leads to inflationary pressures and the other leads to either tax increases or expenditure decreases. However, as Keynes (1923) argues the problem is there are big issues facing the economy in the short run.

References

Aizenman, J., & Pasricha, G.K. (2010). On the ease of overstating the fiscal stimulus in the US, 2008-9, NBER, *Working Paper*, No.15784. doi. 10.3386/w15784

Auerbach, A.J. (2002). Is there a rule for discretionary fiscal policy?, NBER, *Working Paper*, No.9306. doi. 10.3386/w9306

Auerbach, A.J. (2003). Fiscal policy, past and present, *Brookings Papers on Economic Activity*, 2003(1), 75-122. doi. 10.1353/eca.2003.0011

Barro, R.J., & Gordon, D.B. (1983). Positive theory of monetary policy in a natural rate model, *The Journal of Political Economy*, 91(4), 589-610. doi. 10.1086/261167

Bernanke, B.S. (2009). *The Crisis and Policy Response, The Stamp Lecture*, London School of Economic, London.

Bernanke, B.S., & Gertler, M. (2000). Monetary policy and asset price volatility, NBER, *Working Paper*, No.7559. doi. 10.3386/w7559

Bernanke, B.S., & Mihov, I. (1996). What does the Bundesbank target?, NBER, *Working Paper*, No.5764. doi. 10.3386/w5764

Bernanke, B.S., & Mishkin, F.S. (1997). Inflation targeting: A new framework for monetary policy?, *The Journal of Economic Perspectives*, 11(2), 97-116. doi. 10.1257/jep.11.2.97

Bernanke, B.S., & Reinhart, V.R. (2004). Conducting monetary policy at very low short-term interest rates, *The American Economic Review*, 94(2), 85-90. doi. 10.1257/0002828041302118

Benigno, G., & Benigno, P. (2006). Designing targeting rules for international monetary policy cooperation, *Journal of Monetary Economics*, 53(3), 473-506. doi. 10.1016/j.jmoneco.2005.03.009

Blanchard, O.J., Ariccia, G.D., & Mauro, P. (2010). Rethinking macroeconomic policy, *Journal of Money, Credit and Banking*, 42(1), 199–215. doi. 10.1111/j.1538-4616.2010.00334.x

Blinder, A.S. (2010). Quantitative easing: Entrance and exit strategies, *Federal Reserve Bank of St, Louis Review*, 92(6), 465-479.

Blundell-Wignall, A., & Slovik, P. (2011). A market perspective on the European sovereign debt and banking crisis, *OECD Journal: Financial Market Trends*, 2010(2), 225-249.

Brunnermeier, M.K. (2009). Deciphering the liquidity and credit crunch 2007-2008, *The Journal of Economic Perspectives*, 23(1), 77-100. doi. 10.1257/jep.23.1.77

Caceres, C., Guzzo, V., & Segoviano, M. (2010). Sovereign spreads: Global risk aversion, contagion or fundamentals?, International Monetary Fund, *Working Paper*, No.WP/10/120. [Retrieved from

Carmassi, J., & Micossi, S. (2010). The role of politicians in inciting financial markets to attack the Eurozone, Centre for European Policy Studies, *EuropEos Commentary*, No.4.

Chari, V.V., Christiano, L., & Kehoe, P.J. (2008). Fact and myths about the financial crisis of 2008, Federal Reserve Bank of Minneapolis, *Working Paper*, No.666. [Retrieved from].

Clarida, R., Gali, J., & Gertler, M. (1999). The science of monetary policy: A new Keynesian perspective, *Journal of Economic Literature*, 37, 1661-1707. doi. 10.1257/jel.37.4.1661

Devereux, M.B., & Sutherland, A. (2007). Financial globalization and monetary policy, Centre for Economic Policy Research, CEPR, *Discussion Paper*, No.6147. [Retrieved from].

Feldstein, M.S. (2002). Commentary: Is there a role for discretionary fiscal policy, *Federal Reserve Bank of Kansas City Proceedings*, pp.151-162. [Retrieved from].

Feldstein, M.S. (2009). Rethinking the role of fiscal policy, *The American Economic Review: Papers & Proceedings*, 99(2), 556-559. doi. 10.1257/aer.99.2.556

Friedman, M. (1948). A monetary and fiscal framework for economic stability, *The American Economic Review*, 38(1),245-26.

Friedman, M. (1968). The role of monetary policy, *The American Economic Review*, 58, 1-17. doi. 10.1007/978-1-349-24002-9_11

Friedman, M. (1982). Monetary policy: Theory and practice, *Journal of Money, Credit and Banking*, 14(1), 98-118. doi. 10.2307/1991496

Gali, J., & Perotti, R. (2003). Fiscal policy and monetary integration in Europe, *Economic Policy*, 18(37), 533-572. doi. 10.1111/1468-0327.00115_1

Gorton, G.B. (2008). The panic of 2007, NBER, *Working Paper*, No.14358. doi. 10.3386/w14358

Keynes, J.M. (1923). *A Tract on Monetary Reform,* London: Macmillan.

Krishnamurthy, A., & Vissing-Jorgensen, A. (2011). The effects of quantitative easing on interest rates: Channels and implications for policy, NBER, *Working Paper*, No.17555. doi. 10.3386/w17555

Leeper, E.M., & Roush, J.E. (2003). Putting "M" back in monetary policy, *Journal of Money, Credit and Banking*, 35(6), 1217-1256. doi. 10.1353/mcb.2004.0031

Magud, N.E. (2008). On asymmetric business cycles and the effectiveness of counter-cyclical fiscal policies, *Journal of Macroeconomic*, 30(3), 885-905. doi. 10.1016/j.jmacro.2007.02.008

Mishkin, F.S. (2009). Is monetary policy effective during financial crisis?, *The American Economic Review: Papers & Proceedings*, 99(2), 573-577. doi. 10.1257/aer.99.2.573

Mydral, G. (1939). Fiscal policy in the business cycle, *The American Economic Review*, 29(1), 183-193.

Romer, C.D., & Romer, D.H. (1989). Does monetary policy matter? A new test in the spirit of Friedman and Schwartz, *in* O.J. Blanchard, & S. Fischer (eds.), *NBER Macroeconomics Annual 2004*, (pp.121-184), Cambridge (Massachusetts): MIT Press.

Rudebusch, G.D. (2010). The Fed's exit strategy for monetary policy, Federal Reserve Bank of San Francisco, *Economic Letter*, No.2010-18. [Retrieved from].

Rudebusch, G.D. (2010). The Fed's exit strategy for monetary policy, Federal Reserve Bank of San Francisco, *Economic Letter*, No.2010-18. [Retrieved from].

Shiratsuka, S. (2010). Size and composition of the central bank balance sheet: Revisiting Japan's experience of the quantitative easing policy, Federal Reserve Bank of Dallas, Globalization and Monetary Policy Institute, *Working Paper*, No.42. [Retrieved from].

Taylor, J.B. (2008). The state of the economy and principles for fiscal stimulus, testimony before the committee on the budget United States Senate, Accessed: 4 April 2014. [Retrieved from].

Taylor, J.B. (2009a). The financial crisis and the policy responses: An empirical analysis of what went wrong, NBER, *Working Paper*, No.14631. doi. 10.3386/w14631

Taylor, J.B. (2009b). The lack of an empirical rationale for a revival of discretionary fiscal policy, *The American Economic Review*, 99(2), 550-555. doi. 10.1257/aer.99.2.550

Tobin, J. (1971). *Essays in Economics Volume 1: Macroeconomics*, New York: North Holland.
Tobin, J. (1983). Monetary policy in an uncertain World, *BOJ Monetary and Economic Studies*, 1(2), 15- 27.
Woodford, M. (2007). The case for forecast targeting as a monetary policy strategy, *Journal of Economic Perspectives*, 21(4), 3-24. doi. 10.1257/jep.21.4.3

1 Is the sovereign debt market efficient? Evidence from the US and German sovereign debt markets

Introduction

The dominant theory since the early to mid-1960s have been the efficient market hypothesis (EMH), developed through the contributions of prominence articles such as (Malkiel, 1962), (Fama, 1965) and (Fama, 1970). 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 efficiency through the use of prominent tests like the Shiller volatility test proposed by (Shiller, 1981b).

The efficient market hypothesis is based upon the model of perfect competition which is the base of neoclassical economics. Perfect competition implies market participants are assumed to be rational, risk averse and profit maximising. This assumption of market participants' behaviour is extended into the efficient market hypothesis as developed by (Malkiel, 1962) and (Fama, 1965). Especially since the 1990s (Shiller, 2003) behavioural finance gained momentum questioning the efficient market hypothesis.

As we are testing the efficient market hypothesis, we start this chapter by a short review of the efficient market hypothesis. The next section explains the data used. Section 4 gives the empirical test. Section 5 presents the empirical results and Section 6 concludes.

Literature review

According to Fama (1970) the efficient market is a market where investors are assumed to exhibit rational profit-maximization behaviour and prices always fully reflect available information. A consequence of this assumption is that new information spreads quickly and is priced into asset valuation without delay. Hence as Malkiel (2005) states this means that no arbitrage opportunities exists 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 persists. However, this does not mean that the efficient market hypothesis implies market prices will always be accurate and all investors will always exhibit rational profit maximization behaviour.

As suggested by both Fama (1965) and Malkiel (2003), the efficient market hypothesis is associated with the idea of the random walk theory. If bonds prices follow a random walk then they are unpredictable. Hence as Fama (1965) states during periods of uncertainty the equilibrium price can never be determined exactly or in other words, the best forecast is to assume that tomorrow's price is the same as today's. As a result prices and returns are very difficult to forecast (Timmermann & Granger 2004). Ball (2009) hints that believing in the EMH led to the false sense of security by regulators and investors that market prices are correctly based on all information especially in times prior to an asset price bubble. This could ultimately explain the financial crisis. 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). And 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 all the fundamental 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.

Another key argument is that because markets often go through phases 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), 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 points towards the use of the behavioural finance theory.

In this chapter, we will test the efficient market hypothesis from a different point of view. We are interested in the question whether EMH always holds or whether unforeseen and/or uncertain events such as the financial crisis leads to inefficient markets. We chose as sample markets the US and German bonds markets. We are particularly interested in the periods prior to the financial crisis 2008 and afterwards, which led to the Eurozone crisis. The hypothesis is therefore, that if we find only one period where the financial markets are inefficient then a financial market cannot be efficient as a whole.

Methodology

The main aim of this research is to test for the efficient market hypothesis in the sovereign debt market for different periods of time. We opt to test for the EMH by using an extended version of the test originally proposed by Shiller (1979, 1981a), the Shiller Volatility Test.

While the Shiller volatility test, as stated by Shiller (1981b), is based on the key assumption that under the EMH prices incorporate the relevant market information efficiently, thus meaning excess volatility in the market is the result of inefficient markets as hinted by Bollerslev & Hodrick (1992) and Fama (1970). Hence it is essentially a test of the null hypothesis of the excess volatility in the market.

We test for the null of the EMH using both the 2002 and 2007 set of observed prices. In order to analyse the different effects on the EMH in the context of different markets environment, we test for different periods within the 2002 and 2007 issues. To test the EMH for these periods, we use four subsamples across the observed datasets and test them separately. Given the large amount of observations (see below) there is no problem regarding degrees of freedom in the subsamples. So we test the EMH for the whole sample as well as for the subsamples.

The interesting consequence of this is that if a subsample is efficient that does not necessarily mean that the entire sample is efficient. We could have a scenario where over the whole period the market seems to be efficient but during a subsample the market is inefficient or the market could be inefficient but during a subsample the market is efficient. This then leads to the interesting question if and when the EMH holds and where there is any regularity.

In essence the influencing factor underpinning the Shiller volatility test as highlighted by Shiller (1979) is that on some occasions (e.g. crises) price volatility in the financial market exceeds that explained by efficient markets. Hence the markets are not efficient. Using the basis of the Shiller (1979) and LeRoy & Porter (1981) variance bound test methodology, we propose extending the test by using an AR GARCH model in obtaining the key statistics (see also

Musunuru 2014). By using the GARCH model, we omit the need for an optimal price and use the 5 % F-statistics to test the efficient market hypothesis directly.

In essence, the Shiller (1979, 1981a) and LeRoy and Porter (1981) variance bound test is really a test of whether the fundamental value as given by the present value equation, see Eq. 1, does determines the behaviour of the price. The basic argument, as put by Shiller (1992), is any excess volatility is evidence of inefficient markets. However as we will illustrate now there is a big issue regarding the use of the present value model within the bond market. The present value model dictates that the price of a bond based on all coupons is as given by Eq. 1.

$$\boldsymbol{P} = \sum_{t=1}^{T} \frac{C \times PV}{\left(1+\frac{r}{2}\right)^{2t}} + \frac{PV}{\left(1+\frac{r}{2}\right)^{2t}} \tag{1}$$

Where C is the coupon rate, PV is the par value and r is the yield. The problem with this is from all these variables, the only time-varying variable is the yield. Whereas in the stock market the dividend is also time varying, hence the fundamental value of a stock is different from the price. However since the yield in the bond market is derived the price, this means that the price does not differentiate a lot from the fundamental value. So the problem in this model is that the price of the bond will always be approximating (if not equal to) the fundamental value. By omitting the need to calculate the fundamental value and using a simple AR(1)-GARCH (1,1). In order to analyse the efficiency in our observed markets, we need to calculate the daily variance. We use the 20 lag daily price variance in our statistical analysis and tests of the observed sovereign debt markets.

As illustrated by Shiller (1979), the key factor underlying the Shiller volatility test and any variance bound test is the variance calculation. We model our variables as time varying 20 lags variance of the price or excess returns using Eq. 2.

$$\boldsymbol{lim_{t\to T}\, var(x_t)} = \frac{\sum_{q=1}^{Q}(x+\mu)^2}{Q=20} \tag{2}$$

The residuals are estimated using a one lagged autoregression model as illustrated by Eq. 3.

$$\boldsymbol{var(x_t) = \omega + \alpha.var(x_{t-1}) + \varepsilon_t} \tag{3}$$

We set ϵ to be equal to the residuals of the autoregression model. Hence the GARC H is estimated using Eq. 4.

$$var(x_t) = \omega + \alpha.var(x_{t-1}) + \epsilon_t \tag{4}$$

In common with all our GARCH models, we use t-student distribution; hence we estimate a t GARCH (1, 1) using **Hata! Başvuru kaynağı bulunamadı.**.

$$\boldsymbol{h_t = \omega + \alpha k_{t-1} + \beta h_{t-1}} \tag{5}$$

We derive our EMH 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 **Hata! Başvuru kaynağı bulunamadı.**.

$$\boldsymbol{statistics} = \frac{(\alpha+\beta)-1}{SDev(var(x))} \tag{6}$$

Since the market is efficient when the statistics is equal or significantly close to the f statistics, therefore by definition the market is efficient when the condition as set in Eq. 7 is true. Hence we reject the null hypothesis for the EMH if the condition is true but accept the null hypothesis of inefficient markets for anything else.

$$abs\left(\frac{statistics}{f - statistics}\right) \approx 1$$

We use the F-statistics at the 5 % level of 1.96 to establish whether the market is too volatile to reject the null hypothesis of the EMH. There are two key statistics in the output of our GARCH model: the coefficient and standard error of the lagged price variance.

In our test, the EMH test statistic is derived using equation 6. The Null of efficient markets in the observed period is accepted if the result is not exceeding 1.96, otherwise we reject the null hypothesis. Therefore we test the EMH for the overall market and for each period as identified above.

Data description

As illustrated by Table 1 we use the daily US Treasury 10-Year notes and German 10-year Bunds, maturing in 2012 and 2017, end of day bid prices obtained from Bloomberg. We follow the norm by defining our week as Monday to Friday. In order to make the observed data uniformed across both issues, we replace missing or not available prices with the last known price.

Table 1. *The 10-year sovereign debt prices data*

Country	Reference number	Download date	Issue data	Maturity date
Germany 2012	DE000113192	16/07/2012	02/01/2002	31/12/2011
Germany 2017	DE0001135317	08/04/2013	17/11/2006	04/01/2017
US 2012	9128277L0	16/07/2012	15/02/2002	15/02/2012
US 2017	912828GH7	08/04/2013	15/02/2007	15/02/2017

The two issues were chosen so that there would be an overlap in the observations. The first observed sample is from 1st July 2002 to 30th December 2011with a total of 2480 daily observations. Our second sample is from 1st July 2007 to 31st March 2013 with a total of 1500 daily observations.

Emprical evidence

We test the prices of two US Treasury 10-Year notes and German Bunds observed over two periods, the first issue is from 1st July 2002 to 31st December 2011 and the second issue is from 1st July 2007 to 31st March 2013. In order to identify the changes in the market, we also test for the efficient markets in four sub-samples linked with different environments in the sovereign debt market. The first period is between August 2002 and December 2004 which was a highly volatile period mainly due to events ranging from the 11th September 2001 terrorist attacks and ensuing Afghanistan and Iraq wars to the collapse of the dotcom bubble and the ensuing recession. The second period, January 2005 to June 2007, mainly highlight low volatility in the sovereign debt market due to the bubbles in the housing and asset securitization such as MBS and CDO markets brought on by the low interest rates and economic upturn. The third period, July 007 to October 2010, is highlighted by 2007/2008 financial crisis and ensuing economic recession. And the final period is between November 2010 and March 2013 highlighted by the sovereign debt crisis on both sides of the Atlantic.

We used EViews eight to estimate an AR(1)-GARCH(1, 1) model of the sovereign debt market volatility. This empirical section presents the results of or model of price volatility and the tests of the efficient market hypothesis in each period of the two 10-Year notes.

Table 3 and Table **2** illustrate the results of the volatility test using the GARCH model. Where the test statistic is smaller than the critical value the market is efficient. The table shows is that if the entire sample is taken into account the market seems to be efficient for both US bond issues. If however the subsamples are considered then there are periods where the market is efficient and others where it is not. Notably during the financial crisis and Euro crisis the market was not efficient for the 2002 bond. The results indicate that excess volatility was not present prior to the financial crisis. The after math of the 2007 financial crisis results in a higher volatility of the US government bonds. For the 2007 bond the results are distinguished by the financial crisis which points to the market being efficient, although the excess volatility only starts during the Euro crisis.

Table 2. *US Sovereign Bond Market Statistics*

Bond	2012				2017		
Observation	*All*	*01/07/2002 – 29/06/2007*	*02/07/2007 – 30/10/2009*	*02/11/2009 – 30/12/2011*	*All*	*02/07/2007 – 30/10/2009*	*02/11/2009 – 29/03/2013*
				Mean Equation			
a	0.004720 (4.24E-05)	0.002192 (0.000432)	0.004776 (0.000202)	0.004641 (0.000122)	0.009329 (0.000173)	-0.000564 (0.003340)	0.009385 (0.000177)
b	0.981295 (0.000642)	1.002683 (0.001139)	0.975373 (0.001567)	0.981840 (0.003607)	0.993947 (0.000883)	1.006598 (0.003128)	0.987676 (0.000946)
ϵ	0.714328 (0.006116)	0.749997 (0.007591)	0.702917 (0.011493)	0.702702 (0.018872)	0.717657 (0.007993)	0.703845 (0.014809)	0.707102 (0.010624)
				Variance Equation			
ω	3.23E-08 (9.73E-09)	2.68E-05 (5.19E-06)	1.73E-06 (7.57E-07)	1.57E-08 (8.68E-09)	1.38E-06 (4.27E-07)	0.000763 (0.000151)	1.61E-06 (4.73E-07)
α	1.609716 (0.124186)	1.517380 (0.145895)	2.739762 (0.722247)	0.991745 (0.148589)	1.933987 (0.224059)	1.238184 (0.181054)	2.317501 (0.354558)
β	0.282801 (0.015724)	0.168458 (0.022045)	0.191036 (0.031928)	0.243627 (0.047824)	0.246653 (0.224059)	0.126311 (0.045353)	0.164934 (0.021917)
				Model Statistics			
Log Likelihood	7556.608	2716.990	1621.194	3305.380	2926.421	633.739	2335.037
R^2	0.987422	0.985536	0.979268	0.9484793	0.987786	0.984827	0.984020
Jarque-Bera	4324.66	844.25	1311.57	105.76	16546.91	75.00	11650.69
Q-Statistics	611.65	355.85	92.106	182.89	287.04	180.94	172.50
Arch Effect	2.216885	0.445786	0.082282	2.601891	0.000144	2.027137	0.003594
σ^2	0.560344	0.699244	0.223842	0.01774	1.067295	1.444623	0.41962
				EMH Test			
Test Stats	1.592802	0.98	8.625718	13.26787	1.106198	0.252312	3.532803
Efficiency	Accept	Accept	Reject	Reject	Accept	Accept	Reject

As there are periods where the market is clearly not efficient, we cannot conclude that overall the bonds market is efficient. Moreover, it does not seem to be coincidental that the market is inefficient in times of crises and immediately before that. This points to the behavioural finance argument that in times of crises there are over- and/or under reactions of market participants.

The results for the German data sets are different to the US results as can be seen in Table 2. Table 2 shows that for then tire sample the test the German bonds market is inefficient. This is in contrast to the US market. If this result is true then it highlights the limits of spill over effects in terms of an efficient market does not mean that the other markets have to be efficient even though capital restrictions do not exist. However, as there are periods of inefficiency, this outcome of the overall test may simply be a random/biased effect caused by ignoring structural breaks.

Looking at the subsamples there is a period where the market is efficient, namely the Euro crisis period for the 2007 bond issue. Interestingly, all other sub periods were inefficient. This would support the case of perfect capital mobility and linked markets.

Regardless, this result is not necessarily obvious as Germany was not as much affected by the housing bubble as the US (or indeed other European countries). But as investors were looking for safe havens, the volatility of German bonds markets could have increased due higher demand for government bonds.

There is a period where the German market is efficient, however overall the German market seem to be hinting at inefficiency. Hence, one cannot conclude that the German market is always efficient, which means the German market is rather inefficient as in the case of the US to a certain extent.

Table 3. *German Sovereign Bond Market Statistics*

Bond	2012				2017		
Observation	*All*	*01/07/2002 – 29/06/2007*	*02/07/2007 – 30/10/2009*	*02/11/2009 – 30/12/2011*	*All*	*02/07/2007 – 30/10/2009*	*02/11/2009 – 29/03/2013*
Mean Equation							
a	0.001963 (2.46E-05)	0.001080 (0.000333)	0.002287 (0.000271)	0.002091 (5.53E-05)	0.004452 (0.000380)	0.006665 (0.001545)	0.005924 (0.000346)
b	0.990089 (0.000685)	1.010122 (0.001977)	0.973174 (0.001752)	0.993474 (0.001796)	1.003136 (0.001126)	1.005106 (0.002573)	0.975723 (0.001524)
ϵ	0.710886 (0.006884)	0.729650 (0.011164)	0.741932 (0.015975)	0.763513 (0.019155)	0.747491 (0.010197)	0.789827 (0.018080)	0.739618 (0.012980)
Variance Equation							
ω	3.25E-08 (8.60E-09)	1.03E-05 (1.72E-06)	3.71E-06 (8.48E-07)	4.53E-08 (9.45E-09)	2.05E-05 (3.46E-06)	0.000143 (2.52E-05)	7.84E-06 (1.84E-06)
α	1.68348 (0.113878)	1.355465 (0.129580)	1.314567 (0.175964)	1.383852 (0.193950)	1.52365 (0.154555)	1.379988 (0.224340)	1.321697 (0.152443)
β	0.23705 (0.014322)	0.171189 (0.025036)	0.198202 (0.037437)	0.113232 (0.029609)	0.179062 (0.021962)	0.097725 (0.034010)	0.238089 (0.027270)
Model Statistics							
Log Likelihood	8507.083	3435.158	1908.073	3233.428	3350.473	1083.302	2307.666
R^2	0.983304	0.979538	0.979426	0.985310	0.981807	0.976877	0.982091
JB-Stats	5702.64	525.97	97.56	416.19	1392.45	198.89	108.16
Q-Stats	730.76	479.46	218.51	203.53	468.74	203.72	315.52
Arch Effect	3.088917	2.844207	3.249124	5.379326	1.382685	1.025226	5.054297
σ^2	0.216199	0.257346	0.133095	0.013194	0.344854	0.397085	0.257374
EMH Test							
Test Stats	4.25779	2.05	3.852654	37.675	2.037709	1.20305	2.17499
Efficiency	Reject	Reject	Reject	Reject	Reject	Accept	Reject

Our contribution is therefore that we can show that there are mixed results. There are periods of time where markets are efficient and others where they are not. Hence, by not taking structural breaks into account, and testing over an entire sample one may conclude falsely that financial markets are efficient. However, testing over an entire sample may not always result in showing that a market is efficient. As the German example has shown, the result can also be that the financial market overall is inefficient which is also wrong in the sense that it neglects the crucial information that there are periods where the financial markets are efficient.

Hence, omitting structural breaks from an econometric test leads to wrong conclusions. Our results therefore also confirm the results of Hughes Hallett & Richter (2002, 2004) and Bai & Perron (1998). Furthermore, we also showed that crisis times in particular lead to excessive volatile behaviour. This behaviour is, of course, not compatible with the efficient market hypothesis. For the efficient market hypothesis to hold the distinction between "normal" and "not so normal" times does not exist. Hence, if one can prove the existence of only one period where the efficient market hypothesis does not hold the market cannot be efficient.

As a result, we have shown - by other means - that bond prices can deviate from the fundamental value (whatever that is) for a prolonged period of time as suggested by Ball (2009) and Barberis & Thaler (2003). Moreover, it can also be concluded that the efficient market assumptions simply do not hold as it was also shown by De Bondt *et al*. (2008) and Philips (1997).

All of the above are features of crises times where there is a large degree of uncertainty precisely because the full information set is typically not available. Hence, it is not really surprising that in crises times in particular the efficient market hypothesis does not hold.

Conclusion

In this paper, we used the Shiller volatility test to analyse different periods. We used a GARCH(1, 1) to estimate the excess volatility in two of the biggest financial asset markets, the US Treasuries and German Bunds, in a fast changing environment encompassing fixed periods/ samples of high and low volatility.

By using daily data we had enough degrees of freedom to create subsamples where we could test each subsample individually. We then compared the subsample results with the sample results. The aim was to find out how the 2008 financial crisis and 2009 Euro crisis mayor may not have changed the efficiency of financial markets.

Looking at the overall sample results, it seems that the German market and the US market are fundamentally different: The US market seems to be efficient, whilst the German market is not. Looking at the subsamples we see that the periods where the German market is inefficient do to certain extent overlap the US market. Given that both financial markets show periods where they are not efficient, it turns out that both markets are actually inefficient in particular during a crisis period. The results indicate that market participants sometimes over- and/or underreact to news especially in times of crises, but also before the crisis actually happens.

However, it should be pointed out that this does not mean market participants are "irrational". As they are acting under uncertainty and do not have the full information set it is more appropriate speak of bounded rationality as opposed to unbounded rationality.

We could therefore confirm earlier results that financial markets are not as efficient as it is assumed especially in the neoclassical theory. The problem is while both neoclassical economics and the efficient market hypothesis are powerful benchmark tools; they do not reflect the real world.

References

Abreu, D. & Brunnermeier, M.K. (2003). Bubbles and crashes, *Econometrica*, 71(1), 173–204.

Bai, J. & Perron, P. (1998). Estimating and testing linear models with multiple structural changes, *Econometrica*, 66(1), 47–78. doi. 10.2307/2998540

Ball, R. (2009). The global financial crisis and the efficient market hypothesis: What have we learned?, *Journal of Applied Corporate Finance*, 21(4), 8-16. doi. 10.1111/j.1745-6622.2009.00246.x

Barberis, N., & Thaler, R.H. (2003). A survey of behavioral finance, *in* G.M. Constantinides, M. Harris, & R.M. Stulz, (Eds.) *Handbook of the Economics of Finance*. 1st edn. (pp.1053-1127), Amsterdam: Elsevier B.V. doi. 10.1016/S1574-0102(03)01027-6

Blanchard, O., & Watson, M. (1982) Bubbles, Rational Expectations and Financial Markets, *NBER Workiong Paper*. No.945. doi. 10.3386/w0945

Bollerslev, T., & Hodrick, R.J. (1999). Financial market efficiency tests, *in* M.H. Pesaran, & M.R. Wickens, (Eds.) *Handbook of Applied Econometrics. Volume I: Macroeconomics*. (pp.221-311), Oxford, UK: Blackwell Publishing. doi. 10.1111/b.9780631215585.1999.00010.x

De Bondt, W. (2000). The psychology of underreaction and overreaction in World equity marlkets, *in* D.B. Keim, & W.T. Ziemba, (Eds.) *Security Market Imperfections in World Wide Equity Markets*, (pp.65-89), Cambridge: Cambridge University Press. [Retrieved from].

De Bondt, W. *et al.* (2008). Behavioral finance: Quo vadis?, *Journal of Applied Finance*, 18(2), 1-15.

Daniel, K., Hirshleifer, D., & Subrahmanyam, A. (1998). Investor psychology and security market under- and overreactions, *The Journal of Finance*, 53(6), 1839-1885.

Fama, E.F. (1965). Random walks in stock market prices, *Financial Analysts Journal*, 21(5), 55–59. doi. 10.2469/faj.v21.n5.55

Fama, E.F. (1970). Efficient capital markets: A review of theory and empirical work, *The Journal of Finance*, 25(2), 383–417. doi. 10.1111/j.1540-6261.1970.tb00518.x

Hallett, A.H., & Richter, C.R. (2002). Are capital markets efficient? Evidence from the term structure of interest rates in Europe, *Economic and Social Review*, 33(3), 333-356.

Hallett, A.H., & Richter, C.R. (2004). Spectral analysis as a tool for financial policy: An analysis of the short-end of the British term structure, *Computational Economics*, 23(3), 271–288. doi. 10.1023/b:csem.0000022836.40541.9f

Hong, H., & Stein, J.C. (1999). A unified theory of underreaction, momentum trading, and overreaction in asset markets, *The Journal of Finance*, 54(6), 2143–2184. doi. 10.1111/0022-1082.00184

Kourtidis, D., Šević, Ž., & Chatzoglou, P. (2011). Investors' trading activity: A behavioural perspective and empirical results, *Journal of Socio-Economics*, 40(5), 548-557. doi. 10.1016/j.socec.2011.04.008

LeRoy, S.F., & Porter, R.D. (1981). The present-value relation: Tests based on implied variance bounds, *Econometrica*, 49(3), 555–574. doi. 10.2307/1911512

Malkiel, B.G. (1962). Expectations, bond prices, and the term Structure of interest rates, *The Quarterly Journal of Economics*, 76(2), 197-218. doi. 10.2307/1880816

Malkiel, B.G. (2003). The efficient market hypothesis and its critics, *Journal of Economic Perspectives*, 17(1), 59-82.

Malkiel, B.G. (2005). Reflections on the efficient market hypothesis: 30 years later, *The Financial Review*, 40(1), 1-9. doi. 10.1111/j.0732-8516.2005.00090.x

Musunuru, N. (2014). Modeling price volatility linkages between corn and wheat: A multivariate GARCH estimation, *International Advances in Economic Research*, 20(3), 269-280. doi. 10.1007/s11294-014-9477-9

Phillips, R.A. (1997). Stakeholder theory and a principle of fairness', *Business Ethics Quarterly*, 7(1), 51-66. doi. 10.2307/3857232

Shiller, R.J. (1979). The volatility of long-term interest rates and expectations models of the term structure, *Journal of Political Economy*, 87(6), 1190-1219. doi. 10.1086/260832

Shiller, R.J. (1981a). Do stock prices move too much to be justified by subsequent changes in dividends?, *American Economic Review*, 71(3), 421-436.

Shiller, R.J. (1981b). The use of volatility measures in assessing market efficiency, *The Journal of Finance*, 36(2), 291–304. doi. 10.2307/2327010

Shiller, R.J. (1992). *Market Volatilty*. Cambridge, Massachusetts, USA: MIT Press.

Shiller, R.J. (2003). From efficient markets theory to behavioral finance, *Journal of Economic Perspectives*. 17(1), 83–104. Doi. 10.1257/089533003321164967

Timmermann, A., & Granger, C.W.J. (2004). Efficient market hypothesis and forecasting, *International Journal of Forecasting*, 20(1), 15-27. doi. 10.1016/S0169-2070(03)00012-8

2 Testing the efficiency of the sovereign debt market using an asymmetrical volatility test

Introduction

The The efficient market hypothesis has been the cornerstone of asset pricing since the early 1960s, developed through prominence articles such as Malkiel (1962) and Fama (1965, 1970). However as suggested by Fakhry & Richter (2015), the efficient market hypothesis relies on some untestable assumptions and models like perfectly competitive markets and rational risk averse profit maximizing market participants. Hence as suggested by Ball (2009), there have been many criticisms from policy makers and academics, especially in the aftermath of the financial crisis. Yet as hinted by Fakhry & Richter (2015), it is possible to test the efficiency of the market through the use of the Shiller volatility test as derived by Shiller (1981a). Conversely, the momentum of behavioral finance in the 1990s also highlighted the issues surrounding the efficient market hypothesis.

As hinted by Black (1976), a key observation made primarily in stock markets is that there is a negative correlation between returns and volatility, meaning that a negative movement has a greater impact than a positive movement of similar magnitude on the volatility. Therefore, it suggests that market participants react differently to negative and positive shocks. The importance of this is it may have an impact on the efficiency of the market. Fakhry & Richter (2015) hint at a different effect on the efficiency of the market due to the environment. This would suggest that efficiency of the market is based on the reaction of market participants. Hence, we proposed to extend Fakhry & Richter (2015) by using the GJR-GARCH model of volatility as the basis of the variance bound test.

A key issue with the use of issued bonds is that it does lead to accusations of a mismatch between the US and German markets. A better comparison would have been the Eurozone market. However, as of writing the article, there was no issued sovereign debt for the Eurozone. Conversely, many banking and investment firms provide indices for the Eurozone and US sovereign debt markets which could be used instead of the issued sovereign debts. Although the indices do have several major advantages, i.e,. a better comparison between the US and Eurozone markets, longer observational period and overcoming issues such as the onthe-run and maturity effects. Yet the use of these indices in any research would require approval of the issuing firm and we did not have access to the indices during the research.

The recent empirical evidence on the efficient market hypothesis

In testing the efficient market hypothesis, we need to test whether markets follow the random walk model and prices incorporate information immediately. The variance ratio tests of Lo & MacKinlay (1988) allow the testing of the random walk model, the influencing assumption in the weak form efficient market hypothesis. However, a key factor is, as stated by Fama (1970, 1991), any test of the efficient market hypothesis involves a joint hypothesis of the equilibrium expected rates of returns and market rationality. Thus, there is a need to review the variance bound test of Shiller (1979) and LeRoy & Porter (1981) which states any excess volatility in the price of any asset is the result of inefficient markets as argued by Shiller (1992). This would mean that in a rational market, fundamental information is not the driving force of the price and inefficiency in the market drives the price away from the long-term equilibrium.

The concept of the volatility tests is a comparison of the variability of prices with the variability of the future cash flows. The basic argument is that in an ideal world, future cash flows should determine the behavior of prices today; therefore, as Shiller (1992) argues, any excess volatility is evidence of inefficient markets. As emphasized by LeRoy (1989), the underlining factor of the volatility or variance bound tests is that market efficiency dictates that asset price volatility should be relatively low in comparison with returns volatility. Another key factor, highlighted by LeRoy (1989), is that there exists a negative relationship between the variances of the asset price and returns, given the amount of information market participants have. Empirical evidence from Shiller (1979, 1981b) and LeRoy & Porter (1981) suggests that asset prices are more volatile than is consistent with the efficient market hypothesis.

As suggested by Shiller (1981a), a possible test of the model is to use a conventional regression technique and the F-test on the resulting coefficients. However, based on the assumptions made earlier, conventional regression techniques no longer suggest that the likelihood test and the volatility test have more power under certain parameters. Nevertheless, as pointed by Bollerslev & Hodrick (1992) the use of ARCH/GARCH models in the estimation process can overcome seasonality in fundamentals and volatility clustering issues.

In general, there is a large body of empirical literature on the efficiency of the financial market. A large percentage of these are based on the stock market, and 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 that 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 literature 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 that 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.

In a study of the impact of the recent financial and sovereign debt crises on the US and German sovereign debt markets, Fakhry & Richter (2015) found that in general both markets were too volatile to be efficient. Although the US datasets do suggest that the market 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. This leads to a possible explanation of the efficiency of the US datasets using the behavioral 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 and thus giving the impression of market efficiency. Fakhry *et. al*. (2016) found similar evidence using the GIPS markets.

The empirical evidence on the asymmetrical effect in the sovereign debt market

A key observation made primarily in stock markets and also to a lesser extent in the sovereign debt market, there is a negative correlation between returns and volatility as hinted by Black (1976). This means that a negative movement has a greater impact than a positive movement of similar magnitude on the volatility. Glosten *et al.* (1993) proposed a model, aka GJR-GARCH, extending the GARCH-m model to allow for asymmetries in the conditional variance, thus generalizing the GARCH-m to model the leverage-feedback effect. It is essential to note that the GARCH-m is integrated into the GJR-GARCH model which means that when there is no leverage effects the model collapses to a GARCH-m.

However, another model often used to estimate the leverage effect is the EGARCH proposed by Nelson (1991). The key difference is that unlike many other GARCH models where the need arises to constrain the coefficients to ensure the positive conditional variance, the EGARCH model uses the log of the conditional variance. However, as Bollerslev (2008) notes, the inclusion of the log of the conditional variance complicates the unbiased forecasts for the future variances.

The leverage or asymmetrical effect is well documented in the stock markets but little empirical evidence has been documented in the sovereign debt market (e.g. Dungey *et al.* 2009), especially with the 'GJR- GARCH. In a sense Dungey *et al.* (2009) is interesting not only due to the leverage effect research in the sovereign debt market but also to the flight to quality effect. Dungey *et al.* (2009) analyze the leverage effect of flight to quality in respect to the US Treasuries market. Using the asymmetric GARCH model TGARCH (or TARCH) proposed by Zakoian (1994), they explain the positive sign asymmetries found in most flights to quality. During any period of uncertainty such as the recent banking crisis, increasingly risk averse market participants tend to sell high-risk assets and buy low risk assets. As noted by Dungey *et al.* (2009), this leads to low risk asset markets, such as the US Treasuries, exhibiting positive sign asymmetries, i.e. 'a positive price shock in the low risk asset may generate a disproportionately large volatility response', while the high risk asset will suffer from negative asymmetries.

Recently much of the empirical evidence has concentrated on the volatility during the financial or sovereign debt crisis and their effect on the Eurozone. It is important to note that the underlying issue in most of these researches is the effect of the crises on the integration of the financial markets within the Eurozone. Another key issue studied is the contagious effect of the crises especially among the GIIPS nations within the Eurozone due to monetary unification. Good examples of such studies on the effect of the recent crises on the volatility within the Eurozone are Metui (2011), Tamakoshi (2011) and Mohl & Sondermann (2013).

In a chapter researching contagion among the Eurozone sovereign debt markets, Metui (2011) employ the GJR-GARCH model to analyze the effect of news on spread volatility relative to the US Treasury 10 year note yields. They use daily 10-year benchmark yields from 11 core, Eurozone and the US markets obtained from Datastream between 1 April 1999 and 29 April 2011. In concluding, the results seem to be suggesting a strong leverage effect for all countries, hinting at a surprise increase in the yield premia having greater impact than a surprise decline. Using timeline analysis, they illustrate that volatility in the one period ahead 95% VAR seems to correspond with the periods of high financial distress during the recent financial and following sovereign debt crises. They find statistical evidence of contagion in the Eurozone during a credit crisis in one or more countries. This last statement is of importance due to the integrated markets, meaning that sovereign debt crises in small open economies such as Greece, Ireland and Portugal can become systematically important due to contagion links. Concluding, they argue for the implementation of an early warning mechanism for market participants in the sovereign debt market; implementing a periodic stres test on sovereign borrowers.

In an empirical research into the volatility spillover effect of 10-year sovereign debt yields during the Eurozone sovereign debt crisis, Tamakoshi (2011) use a number of AR (k)-EGARCH (p, q) model specifications to fit each of the seven datasets. They use daily 10-year yield data from seven Eurozone members (i.e. GIIPS plus Germany and France) observed over the period between 1st January 2007 and 31st March 2011. They conclude that the analysis points to the existence of short-term spillover effects across the seven Eurozone countries with the biggest pre-crisis spillover coming from Portugal and France. However, the biggest post-crisis spillover came from Portugal and Italy. Although Germany remains the strongest economy and has the best credit rating driven by strong sound fiscal policies, yet the evidence seems to hint at volatility spillover effect from Germany on some Eurozone long-term bond yields. Concluding, this finding has important implications for portfolio diversification in the Eurozone sovereign debt markets.

In a chapter on the impact of political communication on the spreads of the GIIPS nations relative to the German benchmark yields during the Eurozone sovereign debt crisis, Mohl & Sondermann (2013) use an EGARCH model to measure the conditional mean and variance among three categories of political communications concerning restructuring, bailout and the European Financial Stability Facility. They use the daily spreads and news over the period between May 1, 2010 and June 30, 2011 from Haver and a number of news agencies (i.e. Bloomberg, Dow Jones Newswire, Market News International and Reuters). These results seem to be hinting at a limited impact on statements concerning bailouts. However, statements concerning restructuring increased volatility and the EFSF decreased volatility. Their results seem to be indicating statements from major contributing nations about the restructuring seem to have more impact than receiving nations. In contrast, statements on the EFSF from receiving countries have a larger negative impact on the conditional volatility. In concluding, they state that political communication played a key role in the Eurozone crisis. They extend their finding by supporting the calls for an improved communication discipline.

Model specification for the asymmetrical variance bound test

The main aim of this paper is to extend the test for the efficient market hypothesis (EMH) used in Fakhry & Richter (2015) to account for the asymmetrical effect. We proposed an asymmetrical variance bound test by extending Fakhry & Richter (2015) using a GJR-GARCH variant of the variance bound test proposed by Shiller (1979, 1981a). We use the 5% critical value F-statistics to test the efficient market hypothesis. Although Shiller does advocate the use of such methodology, yet he does not specify a specific econometric model. There are a number of pre-requisite steps in the model specification of the test:

1. As illustrated by Shiller (1981a), 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 20 lagged system advocated by Fakhry & Richter (2015).

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

2. The first order autoregressive model estimates the residuals in the econometric model underpinning the test as illustrated by equation (2) and (3)

$$var(Price_t) = a + b_1 var(Price_{t-1}) + \mu_t \tag{2}$$
$$\mu_t = \tau\mu_{t-1} + \varepsilon_t \tag{3}$$

We opt to use the GJR-GARCH model in our tests. An influencing factor in the GJR-GAARCH model is the asymmetrical order, which we set to one. Hence, we estimate a GJR-GARCH (1, 1) using equation (2) and (3).

$$h_{jt} = \omega + \alpha_1 K_{t-1} + \beta_1 h_{t-1} + \gamma_1 k_{t-1} I \tag{4}$$

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

An added and interesting factor with the GJR=GARCH is that we could see whether asymmetrical effect has any impact on the efficiency of the market. The key is the γ coefficient in equation (4) where $\gamma \neq 0$ then there is an asymmetrical effect; if $\gamma > 0$ then there is a leverage effect meaning negative shocks have greater effect than positive shocks. As noted by Alexander (2008:137) and Engle & Patton (2001), there is a story within any member of the GARCH family of volatility models influenced by the coefficients in the variance equation. This means that the reaction and mean reversion of the market shocks to volatility can be naturally interpreted by the two remaining coefficients in equation (4). However, due to the use of the variance of the price as the independent variable in the mean equation, we cannot use the true definition. This means that the use of the price variance had the impact of hiking the α coefficient leading to a massive increase in the volatility's sensitivity to market shocks. In contrast, the β coefficient decreased significantly leading to massive downgrade in the persistence of the volatility in the aftermath of a crisis in the market. The coefficients of the GJR-GARCH model of volatility are also key to our asymmetrical variance bound test. As mentioned earlier in this section, we derive our EMH 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 (5):

$$EMH\ Test \quad = \frac{(\alpha+\beta+\gamma)-1}{standard \quad deviation \ \left(var\,(x)\right)} \leq Fstatistics \qquad (5)$$

By definition, the market is efficient when the condition as set in equation (5) is true. Theoretically, the market is only truly efficient when the EMH test statistics is equal to the f-statistic. Hence, we reject the null hypothesis for the EMH if the condition in equation (5) is true but accept the null hypothesis of the market being too volatile to be efficient for anything else.

Data description

As stated earlier, the data used in the empirical section is the US and German 10-year notes observed from July 1, 2002 to December 31, 2011, meaning a uniformed 2,480 daily observations for each sovereign debt market.

In order to analyze the efficiency of the sovereign debt market under different global market conditions, we subdivide our observed markets into the following periods: pre-crisis period, financial crisis of the late 2000s and sovereign debt crisis of the 2010s.

As illustrated in Table 1, we use the daily 10-year sovereign debt, maturing in 2012, end of day bid prices for US and Germany obtained from Bloomberg. We follow the norm by defining our week as Monday to Friday. In order to make the observed data uniformed across all 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
US	9128277L0	16/07/2012	15/02/2002	15/02/2012

An asymmetrical volatility test

This section aims to provide empirical evidence of the impact of the crises on the efficiency of the financial market. As indicated earlier, the keys to the EMH test statistic are the coefficients and standard deviation of the model of volatility. Hence, in essence, the model used determines the EMH test statistic; in the previous section, we used a GARCH (1, 1) model. In this section, we propose an alternative model to estimate the coefficients and standard errors, the GJR-GARCH model. An influencing factor in the use of the GJRGARCH is the use of the asymmetrical effect to analyze whether our EMH test responses differently to negative and positive shocks. With three exceptions, the model is a single lagged and asymmetrical order GJR-GARCH model with a student *t* distribution estimated using the Maximum Likelihood method with a BHHH optimization algorithm.

Pre-crisis period (07/01/2002-06/29/2007)

The evidence seems to suggest that two different impacts influenced the period. The first impact occurred during the early parts of the pre-crisis subsample and was mainly due to the introduction of the euro and extreme events, which lead to Knightian uncertainty such as the 9/11 terrorist attacks. The second impact occurred during the later stages of the pre-crisis subsample and was mainly due to the asset price bubble. The difference between these two impacts on the sovereign debt market is that the first impact had the impression of a highly volatile market whereas during the asset price bubble the impression was of low volatility and prices in the sovereign debt market.

As illustrated in Table 2, the asymmetrical coefficients for the entire observed markets hint at a negative asymmetrical or leverage effect, eaning that negative shocks have a greater impact on the market than positive shocks of the same magnitude. It is worth noting that a key factor underpinning the impact of an asymmetrical or leverage effect is the decision of the market participants on whether information has a positive or negative impact on the asset. Hence, a possible explanation for the negative asymmetrical coefficients is the indecision of the market participants with respect to the major event of the time; in essence, the introduction of the euro caused a lot of confusion among the market participants. It is worth remembering that high volatility blighted the early part of this period and although there were many highly volatile factors influencing the early parts of this period, the main factor was the introduction of the euro.

Table 2. *EMH Test Statistics*

	US			German		
	Pre-Crisis Period(1)	Financial Crisis Period(2)	Sovereign Debt Crisis Period(3)	Pre-Crisis Period(1)	Financial Crisis Period(2)	Sovereign Debt Crisis Period(3)
Mean Eq.	0.002250	0.004796	0.004611	0.001098	0.001767	0.002075
a	(0.000434)	(0.000204)	(0.000124)	(0.000327)	(0.000190)	(5.62E-05)
b	1.002679	0.974958	0.982766	0.010343	0.987780	0.993822
	(0.001199)	(0.001581)	(0.003688)	(0.002140)	(0.001897)	(0.001896)
u	0.749415	0.699719	0.698886	0.730293	0.682694	0.758883
	(0.007641)	(0.011537)	(0.019263)	(0.011118)	(0.015221)	(0.019859)
Mean Eq.	2.61E-05	1.63E-06	3.43E-08	9.53E-06	1.30E-06	4.39E-08
ω	(5.13E-06)	(7.11E-07)	(8.72E-09)	(1.65E-06)	(4.37E-07)	(9.20E-09)
α	1.617939	3.361139	1.104164	1.508946	1.681302	1.547679
	(0.207861)	(0.941532)	(0.198694)	(0.188876)	(0.305273)	(0.270323)
β	0.171466	0.205077	0.256096	0.180951	0.208881	0.121111
	(0.022344)	(0.033263)	(0.048658)	(0.025875)	(0.034591)	(0.029265)
γ	-0.189597	-1.004381	-0.25853	-0.301401	-0.324167	-0.345743
	(0.243610)	(0.712677)	(0.223850)	(0.223691)	(0.358069)	(0.328016)
Log Likelihood	2717.475	1624.479	3306.247	3433.922	1911.452	3.233.719
R^2	0.985531	0.979223	0.984772	0.979491	0.979442	0.985247
DurbinWatson	0.302877	0.422046	0.321082	0.252705	0.282092	0.227169
ARCH Effect	0.384849	0.106693	2.223018	2.294391	0.900928	0.807272
Jarque-Bera	889.842	1745.368	86.407	539.171	466.861	346.648
Std. Dev	0.699244	0.223842	0.017740	0.257360	0.133095	0.013194
EMH Test	0.857795	5.503145	5.734724	1.509543	4.252722	24.484387
Efficiency	Accept	Reject	Reject	Accept	Reject	Reject

Notes: (1) Pre-Crisis Period: 07/01/2002-06/29/2007. (2) Financial Crisis Period: 07/02/2007-10/30/2009. (3) Sovereign Debt Crisis Period: 11/02/2009-12/30/2011

Another influencing factor is the asset price bubble in the later stages of the period associated with the stable sovereign debt markets and low prices towards the end of the pre-crisis period; hence any negative event amplifies the reaction of the market participants due to their perspectives.

Unlike the US market, the α coefficient of the German market is hinting at relatively low levels of sensitivity to market shocks. In essence, the German market seems to be illustrating the stability of the euro effect on the market. In truth, the US market does not hint at a high level of sensitivity to market shocks. While the US is markedly higher, the assumption is the consideration that the US market is the "risk free" market; hence, it observed some flights to safety during the period. A possible explanation for the low Ћ coefficients is that the stability of the asset price bubble countered the earlier effects of the introduction of the euro and the highly volatile events like the Iraq war. Since during any period of sustained economic upturn, market participants are likely to opt for high earning risky assets such as asset-backed securities, i.e., MBS or CDO, or the equity market. Although, on the face of it, the asymmetrical effect does not seem to have had an impact on the Ћ coefficient, yet on closer inspection as illustrated by Fakhry & Richter (2015), the asymmetrical effect seems to have had a decreasing impact on the sensitivity levels of all the markets.

The β coefficients seem to be hinting at relatively low volatility persistence in the aftermath of a crisis in the market, especially the US market. This is not surprising since in general highly persisting events did not affect this period, of course, the moderate levels accounted for some persisting events like the "war on terror". As pointed by Fakhry & Richter (2015), the addition of the asymmetrical effect does seem to have affected the levels of persistence in the observed markets. Essentially, the asymmetrical effect had increased the persistent levels thru all the observed markets.

It is worth noticing that both observed markets accept the efficient market hypothesis. However, interestingly the inclusion of the asymmetrical effect has decreased the EMH test statistics for all the observed markets as pointed by Fakhry & Richter (2015). Conversely, this reduction led to the acceptance of the efficient market hypothesis by German market. Interestingly the German market is closer to the key f- statistics. Although the US market is further away from the key statistic, yet it is efficient. A key explanation for this is the standard deviation, which is higher than all the other markets. This is essential because the larger the standard deviation is the more unpredictable the market, hence the US market was the most unpredictable during the pre-crisis period. Since one of the key assumptions of the efficient market hypothesis is that markets are unpredictable, which means that the US market had satisfied one of the key assumptions. In essence, the difference between being efficient and not was maybe the reaction to a certain event or events.

Financial crisis period (07/02/2007-10/30/2009)

In 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, which resulted in flights to liquidity and quality. As the financial crisis spread, the credit market froze, and therefore non-financial corporations could not find the money required and hence the crisis spread to the equity and corporate bonds market. In essence, this meant an increase in market activities in the observed markets as market participants sought the safety of the sovereign debt market.

During the financial crisis period, the asymmetrical coefficients were hinting at a leverage effect for all the observed markets as illustrated in Table 2. The effect seems to be significant in both markets. However, the asymmetrical coefficient of the US market is significantly high hinting at a large movement in the market volatility following a negative shock to the market. Given that during the financial crisis the prices of sovereign debt did consistently deviate from the expected price due to market participants engaging in flight to safety from risky assets such as MBS, CDO and shares and bonds of financial firms. It is worth remembering that the prices of these assets plummeted, especially in the aftermath of the Lehman Brothers bankruptcy on September 15, 2008, an example is the Dow Jones Average index, which fell from 13,950 on July 16, 2007 to 6,547 on March 9, 2009. This partly explains the high leverage effect in the US market and to a lesser extent the German market which is the risk free market in the Eurozone.

The α coefficients are interesting because they truly reflect the different impact of the financial crisis on the observed sovereign debt markets, and whereas the Ћ coefficient seems to be illustrating the obviously high levels of sensitivity to market shocks in the US market during the financial crisis. What is more interesting with the Ћ coefficient of the US market is that it is the highest of all the observations. This points to a huge impact on the levels of sensitivity to market shocks. The German market seems to be hinting at a limited impact from the financial crisis. However, as illustrated by Fakhry & Richter (2015), certainly the asymmetrical effect had the impact of raising the levels of sensitivity to shocks in both observed markets.

The β coefficients of the US and German markets hint at a high level of volatility persistence during the financial crisis. This is expected, since the US and German markets were regarded as high quality and liquid markets, hence during the financial crisis these markets experienced a constant flight to safety. This leads to high levels of persistence since the volatility is consistently high. Not surprisingly during the financial crisis as illustrated by Fakhry & Richter (2015), the asymmetrical effect had the impact of rising the β coefficients of all the observed markets and hence the levels of persistence in the markets.

The EMH test statistics seem to be hinting at the acceptance of the null hypothesis of the market being too volatile to be efficient in the observed markets. The EMH test statistics imply that the market is deviating from the fundamental value. Since the financial crisis meant that market participants were engaging in flights to liquidity or quality, this meant that prices were trending upwards faster than the fundamental value. This means that the EMH test statistics significantly rejected the efficient market hypothesis for all the observed markets. A key factor in the deviation from the fundamental value was that market participants were reacting to events instead of the fundamentals. Furthermore, as explained in the previously, the continued upwards trend meant that in essence the markets were predictable to a certain extent. As Fakhry & Richter (2015) hints, the inclusion of the asymmetrical effect did not have a significant impact on the EMH test statistics. Having said that, the EMH test statistic for the German market seems to be going against the norm for this period in deviating further from the efficient market.

Sovereign debt crisis period (11/02/2009-12/30/2011)

Essentially, the sovereign debt crises was the product of the governments providing much needed capital for the banking system and following a fiscal stimulus policy to support the economy after the financial crisis. This added a substantial amount to an already large total debt. However, an influencing factor to bear in mind is the maturity effect. Another influencing factor is that in order to provide liquidity and boost the economy, many central banks embarked on a quantitative easing policy; this helped maintain the artificially high prices and more importantly low yields in both markets especially the US.

The asymmetrical coefficients in Table 2 are indicating a leverage effect during the period accounting for the sovereign debt crisis. The evidence seems to be pointing at a significant leverage effect. Not surprisingly, the Ћ coefficients of the US and German markets hint at relative low levels of sensitivity to market shocks during the sovereign debt crisis. In essence, the US and to a lesser extent German markets were not effect by the early stages of the crisis, hence the low levels of sensitivity to market shocks. It is worth remembering that both markets were seen as safe havens from the crisis. However, the asymmetrical effect did have an impact on the Ћ coefficients for both markets raising the levels of sensitivity to market shocks.

The β coefficients for both markets seem to be painting a rather mixed picture. While the US market seems to be suggesting a high level of persistence in the market, the German market seems to be hinting at a lesser level of persistence. A possible explanation for the mixed picture is the different policies adopted by the Federal Reserve and the ECB. Another factor is the beginning of the fiscal cliff crisis in the US which meant that the US market experienced a longer period of volatility. However, this does not explain the relatively low persistence in the German market. A possible explanation is the strength of the German economy. As illustrated by Fakhry & Richter (2015), the inclusion of asymmetrical effect seems to have increased the volatility persistence of the observed markets in the aftermath of a shock.

With the exception of the Greek and Portuguese markets, the EMH test statistics seem to be hinting at the acceptance of the null hypothesis of the market being too volatile to be efficient. All the observed inefficient markets have EMH test statistics that are significantly greater than the F-statistic. As hinted previously, during the financial crisis the market participants were reacting to events instead of the fundamentals. Interestingly, the fundamentals of the sovereign debt markets were already highlighting many issues such as high longer-term unemployment and high debt/deficit. However, hindsight is a lovely tool to have but unfortunately, during any crisis, human nature dictates that market participant react to events rather than the fundamentals of the asset, which was the case during the financial crisis and to a certain extent the sovereign debt crisis. This is the key to understanding the significant acceptance of the null hypothesis of the markets being too volatile to be efficient, especially the German market. During the early stages of the sovereign debt crisis, both markets were seen as risk free and liquid markets, hence the upwards trend continued making them more predictable. Conversely, the EMH test statistic for the German market is significantly higher than the US market, with the inclusion of the asymmetrical effect hinting at a large deviation from the efficient market as pointed by Fakhry & Richter (2015).

Conclusion

In this chapter, we use the Shiller volatility test to analyze the efficiency of the market during different periods. In order to analyze the impact of the asymmetrical effect on the efficiency of the market, we extended Fakhry & Richter (2015) in using a GJR-GARCH. We estimate the excess volatility in two of the biggest financial asset markets, the US Treasuries and German Bunds, in a fast changing environment encompassing fixed periods of high and low volatility. By using daily data, we have enough degrees of freedom to create subsamples where we could test each subsample individually. The aim is to find out how the financial crisis of 2008 and the sovereign debt crisis of 2009 may or may not have changed the efficiency of the financial markets.

Our results show asymmetrical effects on the EMH. In comparison to the results in Fakhry & Richter (2015), the EMH test statistics appear to have increased in general. This meant that the German market accepted the efficient market hypothesis during the pre-crisis period whereas under the GARCH-based test the German market (narrowly) rejected the EMH. However, both the financial and sovereign debt crisis periods did reflect the efficiency status of Fakhry & Richter (2015) in the sense that in "normal times" the EMH holds, whilst in crises times it does not.

A relevant factor raised by our empirical evidence regarding the efficient market hypothesis is that during some highly volatile periods some markets rejects the null hypothesis of the market efficiency due to too volatile behavior. According to Kirchler (2009), underreaction and/or overreaction occurs 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 when it actually is not. This is what seems to have happened during these periods as market participants overreacted to new information, which reflects a regime switching model.

From here are at least two lines of prospective research: the first is to use a switching GARCH model to analyze the impact of high and low volatility on the efficiency of the market. The second is as proposed in the introduction to use an index of the sovereign debt market to better analyze and compare the markets. A major benefit of the use of an index is that it allows us to do a better comparison with the use of the Eurozone sovereign debt index as opposed to the issued German sovereign debt. Another advantage with the use of an index is that it has a longer period of observation, this means we analyze the impact of the Euro on the efficiency of the sovereign debt market. Overall, our results show that market participants were acting under uncertainty and lack of full information. Therefore, the results are backing the conclusions of Fakhry & Richter (2015) in that it is more appropriate to speak of bounded rational behavior than irrationality. This further confirms that financial markets are not as efficient as assumed, especially in the neoclassical theory.

References

Alexander, C. (2008). Introduction to GARCH models. *Market Risk Analysis, Practical Financial Econometrics*, 2, 131-199.

Ball, R. (2009). The global financial crisis and the efficient market hypothesis: What have we learnt? *Journal of Applied Corporate Finance*, 21(4), 8-16, doi. 10.1111/j.1745-6622.2009.00246.x

Black, F. (1976). Studies of stock market volatility changes. *Proceedings of the Business and Economic Statistics Section*, (pp.177-181), American Statistical Association.

Bollerslev, T. (1986). Generalized autoregressive conditional heteroskedasticity. *Journal of Econometrics*, 1(3), 307-327. doi. 10.1016/0304-4076(86)90063-1

Bollerslev, T. & Hodrick, R.J. (1992). Financial market efficiency tests. *National Bureau of Economic Research*, Working Paper No. 4108. doi. 10.3386/w4108

Cajueiro, D.O., Gogas, P. & Tabak, B.M. (2009). Does financial market liberalization increase the degree of market efficiency? The case of the Athens stock exchange. *International Review of Financial Analysis*, 18(1-2), 50–57, doi. 10.1016/j.irfa.2008.11.004

Cuthbertson, K. & Hyde, S. (2002). Excess volatility and efficiency in French and German stock markets. *Economic Modelling*, 19(3), 399-418, doi. 10.1016/S0264-9993(01)00069-4

Dungey, M., Fry, R., Gonzalez-Hermosillo, B., & Martin, V. (2007). Contagion in global equity markets in 1998: The effects of the Russian and LTCM crises. *The North American Journal of Economics and Finance*, 18(2), 155-174. doi. 10.1016/j.najef.2007.05.003

Engle, R.F., & Patton, A.J. (2001). What good is a volatility model? *Quantitative Finance*, 1(2), 237-245.

Fakhry, B., & Richter, C. (2015). Is the sovereign debt market efficient? Evidence from the US and German sovereign debt markets. *International Economics and Economic Policy*, 12(3), 339-357. doi. 10.1007/s10368-014-0304-9

Fakhry, B., Masood, O., & Bellalah, M. (2016). The efficiency of the GIPS sovereign debt markets during a crisis. *International Journal of Business*, 2(1), 87-98.

Fama, E.F. (1965). Random walks in stock market prices. *Financial Analyst Journal*, 21(5), 55-59. doi. 10.2469/faj.v51.n1.1861

Fama, E.F. (1991). Efficient capital markets: II. *The Journal of Finance*, 46(5), 1575-1617. doi. 10.1111/j.1540-6261.1991.tb04636.x

Glosten, L.R., Jagannathan, R., & Runkle, D.E. (1993). On the relation between the expected value and the volatility of the nominal excess returns on stocks. *Journal of Finance*, 48(5), 1779-1801. doi. 10.1111/j.1540-6261.1993.tb05128.x

Kirchler, M. (2009). Underreaction to fundamental information and asymmetry in mispricing between bullish and bearish markets. An experimental study. *Journal of Economic Dynamics and Control*, 33(2), 491-506. doi. 10.1016/j.jedc.2008.08.002

LeRoy, S.F. (1989). Efficient capital markets and martingales. *Journal of Economic Literature*, 27(4), 1583-1621.

LeRoy, S.F., & Porter, R.D. (1981). The present-value relation: Tests based on implied variance bounds. *Econometrica*, 49(3), 555-574. doi. 10.2307/1911512

Lo, A.W., & MacKinlay, C. (1988). Stock market prices do not follow random walks: Evidence from a simple specification test. *The Review of Financial Studies*, 1(1), 41-66. doi. 10.1093/rfs/1.1.41

Malkiel, B. G. & Fama, E. F. (1970). Efficient capital markets: A review of theory and empirical work. *The Journal of Finance*, 25(2), 383-417. doi. 10.1111/j.1540-6261.1970.tb00518.x

Malkiel, B.G. (1962). Expectations, bond prices, and the term structure of interest rates. *The Quarterly Journal of Economics*, 76(2), 197-218. doi. 10.2307/1880816

Metiu, N. (2011). The EMU in debt distress: Contagion in sovereign bond market. *European Economic Association & Econometric Society 2011 Parallel Meetings*, Oslo, 25-29 August.

Mohl, P., & Sondermann, D. (2013). Has political communication during the crisis impacted sovereign bond spreads in the euro area? *Applied Economics Letters*, 20(1), 48-61. doi. 10.1080/13504851.2012.674201

Nelson, D.B. (1991). Conditional heteroscedasticity in asset returns: A new approach. *Econometrica*, 59(2), 347-370. doi. 10.2307/2938260

Shiller, R.J. (1979). The volatility of long-term interest rates and expectations models of the term structure. *The Journal of Political Economy*, 87(6), 1190-1219. doi. 10.1086/260832

Shiller, R.J. (1981a). The use of volatility measures in assessing market efficiency. *The Journal of Finance*, 36(2), 291-304. doi. 10.1111/j.1540-6261.1981.tb00441.x

Shiller, R.J. (1981b). Do stock prices move too much to be justified by subsequent changes in dividends?, *The American Economic Review*, 71(3), 421- 436.

Shiller, R.J. (1992). *Market Volatility*. Cambridge, Massachusetts: MIT Press.

Tamakoshi, G. (2011). European sovereign debt crisis and linkage of long-term government bond yields. *Economics Bulletin*, 31(3), 2191-2203.

Zakoian, J.M. (1994). Threshold heteroskedastic models. *Journal of Economic Dynamics and Controls*, 18(5), 931-955. doi. 10.1016/0165-1889(94)90039-6

Zunino, L., Bariviera, A.F., Guercio, M.B., Martinez, L.B. & Rosso, O.A. (2012). On the efficiency of sovereign bond markets. *Physica A*, 391(18), 4342-4349, doi. 10.1016/j.physa.2012.04.009

3 Testing the efficiency of the GIPS sovereign debt markets using an asymmetrical volatility test

Introduction

The efficient market hypothesis has been the cornerstone of asset pricing since the early, developed through prominence articles such as Malkiel (1962) and Fama (1965; 1970). However as suggested by Fakhry & Richter (2015), the efficient market hypothesis relies on some untestable assumptions and models like perfectly competitive markets and rational risk averse profit maximising market participants. Hence, as suggested by Ball (2009), there have been many objections from policy makers and academics, especially in the aftermath of the financial crisis. Yet as hinted by Fakhry & Richter (2015), it is possible to test the efficiency of the market through the use of the Shiller volatility test as derived by Shiller (1981a). Conversely, the momentum in the 1990s of behavioural finance also highlighted the issues surrounding the efficient market hypothesis.

As hinted by Black (1976), a key observation made primarily in stock markets, there is a negative correlation between returns and volatility. Thus meaning a negative movement has a greater impact than a positive movement of similar magnitude on the volatility. Therefore, suggesting market participants react differently to negative and positive shocks. The importance of this is it may have an impact on the efficiency of the market. Fakhry & Richter (2015) highlighted a different effect on the efficiency of the market due to the environment. This would suggest that efficiency of the market is based on the reaction of market participants. Hence, we propose to extend Fakhry & Richter (2015) by using the GJR-GARCH model of volatility as the basis of variance bound test, hence introducing the asymmetrical volatility test.

As we are analysing the impact of asymmetrical effects on the efficient market hypothesis, we start this paper with two short reviews of the recent empirical evidence of market efficiency and asymmetrical effects. The next section gives methodology of the asymmetrical volatility test. Section 5 and 6 presents the data and empirical results. Finally, section 6 concludes.

The recent empirical evidence on the efficient market hypothesis

In testing the efficient market hypothesis, a common test is to test whether markets follow the random walk model and prices incorporate information immediately. The variance ratio tests of Lo & MacKinlay (1988) allow the testing of the random walk model, the influencing assumptionin the weak form efficient market hypothesis. However, a key factor is as stated by Fama (1970; 1991), any test of the efficient market hypothesis involves a joint hypothesis of the equilibrium expected rates of returns and market rationality. Thus, there is a need to review the variance bound test of Shiller (1979) and LeRoy & Porter (1981) which states any excess volatility in the price of any asset is the result of inefficient markets as argued by Shiller (1992). This would mean that in a rational market, fundamental information is not the driving force of the price and inefficiency in the market drives the price away from the long-term equilibrium.

The rationale of the volatility tests is a comparison of the variability of prices with the variability of the future cash flows. The basic argument is that in an ideal world, future cash flows should determine the behaviour of prices today; therefore, as Shiller (1992) argues, any excess volatility is evidence of inefficient markets. As emphasized by LeRoy (1989), the underlining factor of the volatility or variance bound tests is that market efficiency dictates that asset price volatility should be relatively low in comparison with returns volatility. Another key factor, highlighted by LeRoy (1989), is there exists a negative relationship between the variances of the asset price and returns given the amount of information market participants have. Empirical evidence from Shiller (1979; 1981b) and LeRoy & Porter (1981) suggests asset prices are more volatile than is consistent with the efficient market hypothesis.

Shiller (1981a) suggested using conventional regression techniques and the F-test on the resulting coefficients. However, based on the assumptions made earlier, it can be shown that volatility test have more power under certain circumstances. Nevertheless, as pointed by Bollerslev & Hodrick (1992) the use of ARCH/GARCH models in the estimation process can overcome seasonality in fundamentals and volatility clustering issues.

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) studied the impact of the recent financial and sovereign debt crises on the US and German sovereign debt markets and found both markets were too volatile to be efficient. Although the US datasets do suggest the market may be efficient over the entire sample, 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.

The empirical evidence on the asymmetrical effect in the sovereign debt market

A key observation made primarily in stock markets and also to a lesser extent in the sovereign debt market, there is a negative correlation between returns and volatility as hinted by Black (1976). Thus meaning a negative movement has a greater impact than a positive movement of similar magnitude on the volatility. Glosten *et al.* (1993) proposed a model, aka GJR-GARCH, extending the GARCH-m model to allow for asymmetries in the conditional variance, thus generalising the GARCH-m to model the leverage-feedback effect. It is essential to note that the GARCH-m is integrated into the GJR-GARCH model which mean that when there is no leverage effects the model collapses to a GARCH-m.

However, another model often used to estimate the leverage effect is the EGARCH proposed by Nelson (1991). The key different is that unlike many other GARCH models where the need arises to constraints the coefficients to ensure the positive conditional variance, the EGARCH model uses the log of the conditional variance. However, as Bollerslev (2008) notes the inclusion of the log of the conditional variance complicates the unbiased forecasts for the future variances.

The leverage or asymmetrical effect is well documented in the stock markets but little empirical evident have been documented in the sovereign debt market e.g. Dungey et al. (2009), especially with the GJR-GARCH. In a sense Dungey *et al.* (2009) is interesting not only due to the leverage effect research in the sovereign debt market but also to the flight to quality effect. Dungey et al. (2009) analyse the leverage effect of flight to quality in respect to the US Treasuries market. Using the asymmetric GARCH model TGARCH (or TARCH) proposed by Zakoian (1994), they explain the positive sign asymmetries find in most flights to quality. During any period of uncertainty such as the recent banking crisis, increasingly risk averse market participants tend to sell high-risk assets and buy low risk assets. As noted by Dungey *et al.* (2009), this leads to low risk asset markets, such as the US Treasuries, exhibiting positive sign asymmetries i.e. '*a positive price shock in the low risk asset may generate a disproportionately large volatility response*'. While the high risk asset will suffer from negative asymmetries.

Recently much of the empirical evident have concentrated on the volatility during the financial or sovereign debt crisis and their effect on the Eurozone. It is important to note that the underlying issue in most of these researches is the effect of the crises on the integration of the financial markets within the Eurozone. Another key issue studied is the contagious effect of the crises especially among the GIIPS nations within the Eurozone due to monetary unification. Good examples of such studies on the effect of the recent crises on the volatility within the Eurozone are Dotz & Fisher (2011), Metui (2011), Tamakoshi (2011) and Mohl & Sondermann (2013).

In a paper researching contagion among the Eurozone sovereign debt markets, Metui (2011) employ the GJR-GARCH model to analyse the effect of news on spread volatility relative to the US Treasury 10 year note yields. They use daily 10-year benchmark yields from 11 core, Eurozone and the US markets obtained from Datastream between 1April 1999 and 29 April 2011. In concluding, the results seem to be suggesting a strong leverage effect for all countries; hinting at a surprise increase in the yield premia having greater impact than a surprise decline. Using timeline analysis they illustrate that volatility in the one period ahead 95% VaR seem to correspond with the periods of high financial distress during the recent financial and following sovereign debt crises. They find statistical evident of contagion in the Eurozone during a credit crisis in one or more countries. This last statement is of importance due to the integrated markets meaning sovereign debt crises in small open economies such as Greece, Ireland and Portugal can become systematically important due to contagion links. Concluding, they argue for the implementation of an early warning mechanism for market participants in the sovereign debt market; implementing a periodic stress test on sovereign borrowers.

In an empirical research into the volatility spillover effect of 10-year sovereign debt yields during the Eurozone sovereign debt crisis, Tamakoshi (2011) use a number of AR (k)-EGARCH (p, q) model specifications to fit each of the seven datasets. Theyuse daily 10-year yield data from seven Eurozone members (i.e. GIIPS plus Germany and France) observed over the period between 1 January 2007 and 31 March 2011. He concludes that the analysis points to the existence of short-term spillover effects across the seven Eurozone countries with the biggest pre-crisis spillover coming from Portugal and France. However, the biggest post-crisis spillover comes from Portugal and Italy. Although Germany remains the strongest economy and has the best credit rating driven by strong sound fiscal policies, yet the evident seem to hint at volatility spillover effect from Germany on some Eurozone long-term bond yields. Concluding, this finding has important implications for portfolio diversification in the Eurozone sovereign debt markets.

In a study by Mohl & Sondermann (2013) on the impact of political communication on the spreads of the GIIPS nations relative to the German benchmark yields during the Eurozone sovereign debt crisis. They use an EGARCH model to measure the conditional mean and variance among three categories of political communications concerning restructuring, bailout and the European Financial Stability Facility. They use the daily spreads and news over the period between 1st May 2010 and 30th June 2011 from Haver and a number of news agencies (i.e. Bloomberg, Dow Jones Newswire, Market News International and Reuters). The results seem to be hinting at a limited impact on statements concerning bailouts. However, statements concerning restructuring increased volatility and the EFSF decreased volatility. Their results seem to be indicating statements from major contributing nations about the restructuring seem to have more impact than receiving nations. In contrast, statements on the EFSF from receiving countries have a larger negative impact on the conditional volatility. In concluding, they state that political communication played a key role in the Eurozone crisis. They extend their finding by supporting the calls for an improve communication discipline.

The model specification of the asymmetrical volatility test

The main aim of this paper is to extend the test for the efficient market hypothesis (EMH) used in Fakhry & Richter (2015) to account for the asymmetrical effect. We proposed an asymmetrical variance bound test by extending Fakhry & Richter (2015) using a GJR-GARCH variant of the variance bound test proposed by Shiller (1979; 1981a). We use the 5% critical value F-statistics to test the efficient market hypothesis. Although Shiller does advocate the use of such methodology, yet he does not specify a specific econometric model. There are a number of pre-requisite steps in the model specification of the test:

1. As illustrated by Shiller (1981a), 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 20 lagged system advocated by Fakhry & Richter (2015).

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

2. The first order autoregressive model estimates the residuals in the econometric model underpinning the test as illustrated by equation 2.

$$var(Price_t) = a + b_1 var(Price_{t-1}) + u_t \quad (2)$$
$$u_t = \rho u_{t-1} + \epsilon_t$$

We opt to use the GJR-GARCH model in our tests. An influencing factor in the GJR-GAARCH model is the asymmetrical order, which we set to one. Hence, we estimate a GJR-GARCH (1, 1) using equation 2.

$$h_{jt} = \omega + \alpha_1 k_{t-1} + \beta_1 h_{t-1} + \gamma_1 k_{t-1} I\left(\varepsilon_{jt-1} < 0\right) \quad (3)$$

An added and interesting factor with the GJR=GARCH is that we could see whether asymmetrical effect has any impact on the efficiency of the market. The key is the γ coefficient in equation 3 where $\gamma \neq 0$ then there is an asymmetrical effect; if $\gamma > 0$ then there is a leverage effect meaning negative shocks have greater effect than positive shocks.

As noted by Alexander (2008, p.137) and Engle & Patton (2001), there is a story within any member of the GARCH family of volatility models influenced by the coefficients in the variance equation. This means the reaction and mean reversion of the market shocks to volatility can be naturally interpreted by the two remaining coefficients in equation 3. However, due to the use of the variance of the price as the independent variable in the mean equation, we cannot use the true definition. This means the use of the price variance had the impact of hiking the α coefficient leading to a massive increase in the volatility's sensitivity to market shocks. In contrast, the β coefficient decreased significantly leading to massive downgrade in the persistence of the volatility in the aftermath of a crisis in the market.

The coefficients of the GJR-GARCH model of volatility are also key to our asymmetrical variance bound test. As mentioned earlier in this section, we derive our EMH 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 4:

$$EMH\ Test = \frac{(\alpha+\beta+\gamma)-1}{standard\ \ deviation\ \left(var\,(x)\right)} \leq Fstatistics \qquad (4)$$

By definition, the market is efficient when the condition as set in equation 4 is true. Theoretically, the market is only truly efficient when the EMH test statistics is equal to the f-statistic. Hence, we reject the null hypothesis for the EMH if the condition in equation 4 is true but accept the null hypothesis of the market being too volatile to be efficient for anything else.

Data description

This section aims to provide empirical evidence of the impact of the crises on the efficiency of the financial market. The section will analyse the GIPS sovereign debts markets over a 10-year notes observed from 1st June 2007 to 30th December 2011 meaning a uniformed 1196 daily observations for each sovereign debt market.

In order to analyse the efficiency of the sovereign debt market under different global market conditions, we subdivide our observed markets into the following periods: financial crisis of the late 2000s and sovereign debt crisis of the 2010s.

As illustrated by table 1, we use the daily 10-year sovereign debt, maturing in 201F2, end of day bid prices for

Greece, Italy, Portugal and Spain obtained from Bloomberg. We follow the norm by defining our week as Monday to Friday. In order to make the observed data uniformed across all observed datasets, we substitute all missing observations with the last known price.

Table 1. *The 10-Year Sovereign Debt Prices Data*

	Reference Number	Download Date	Issue Date	Maturity Date
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

Empirical evidence

As indicated earlier, the keys to the EMH test statistic are the coefficients and standard deviation of the model of volatility. Hence, in essence, the model used determines the EMH test statistic; in the previous section, we used a GARCH (1, 1) model. In this section, we propose an alternative model to estimate the coefficients and standard errors, the GJR-GARCH model. An influencing factor in the used of the GJR-GARCH is the use of the asymmetrical effect to analyse whether our EMH test responses differently to negative and positive shocks.

With three exceptions, the model is a single lagged and asymmetrical order GJR-GARCH model with a student t distribution estimated using the Maximum Likelihood method with a BHHH optimization algorithm. However, due to an error in the Portuguese market with the estimation in table 3, we used normal distribution and Marquandt optimization.

Financial crisis period (02/07/2007-30/10/2009)

Table 2 illustrate the impact from the financial crisis of the late 2000s. In 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, which resulted in flights to liquidity and quality. As the financial crisis spread, the credit market froze therefore non-financial corporations could not find the money required and hence the crisis spread to the equity and corporate bonds market. In essence, this meant an increase in market activities in the observed markets as market participants sought the safety of the sovereign debt market.

During the financial crisis period, the asymmetrical coefficients were hinting at a leverage effect for all the observed markets. With the exception of the Greek market, the effect seems to be significant. Given that during the financial crisis the prices of sovereign debt did consistently deviate from the expected price due to market participants engaging in flight to safety from risky assets such as MBS, CDO and shares and bonds of financial firms. It is worth remembering that the prices of these assets plummeted, especially in the aftermath of the Lehman Brothers bankruptcy on 15th September 2008, an example is the Dow Jones Average index, which fell from 13,950 on 16th July 2007 to 6,547 on 9th March 2009. It must be noted that as previously stated the size and liquidity of the Greek market meant that the impact from any event during the financial crisis did not have a large impact on the asymmetrical coefficient which meant a near zero leverage effect.

Table 2. *EMH Test Statistics (02/07/2007-30/10/2009)*

	Greek	Italian	Portuguese	Spanish
Mean Equation a	0.015970 (0.000487)	0.001989 (0.000257)	0.005261 (0.000405)	0.002262 (0.000248)
b	0.998053 (0.001793)	0.997661 (0.001765)	0.991626 (0.001820)	1.000558 (0.001707)
u	0.781356 (0.012194)	0.799973 (0.011800)	0.819527 (0.013501)	0.713470 (0.013905)
Variance Equation ω	1.49E-05 (2.94E-06)	4.49E-06 (9.00E-07)	1.49E-05 (2.50E-06)	4.19E-06 (1.08E-06)
α	1.56118 (0.245778)	1.844676 (0.335691)	1.51262 (0.275942)	2.257028 (0.462730)
β	0.089461 (0.026248)	0.061464 (0.023683)	0.075603 (0.023654)	0.098107 (0.027931)
γ	-0.044722 (0.368074)	-0.113284 (0.430284)	-0.209147 (0.331943)	-0.177109 (0.520074)
Statistics Log Likelihood	1675.797	2016.549	1817.726	1794.128
R^2	0.976535	0.980444	0.978762	0.978033
Durbin-Watson	0.226378	0.296900	0.282623	0.283269
ARCH Effect	4.926133	0.156402	1.488080	0.019445
Jarque=Bera	81.04782	333.7555	77.13293	2278.619
Std. Deviation	0.189977	0.116066	0.157186	0.141228
EMH Test Statistics	3.189433	6.831079	2.41164	8.341306
Efficiency	Reject	Reject	Reject	Reject

The α coefficients are interesting because they reflect the different impacts of the financial crisis on the observed sovereign debt markets. Interestingly, the Spanish mark 0.001820et, which was the most affected by the financial crisis within the Eurozone, and does point to a significantly large level of sensitivity to market shocks. However, with the possible exception of the Italian market, the sensitivity levels of the remaining markets did not increase significantly. As explained in Fakhry *et al.* (2016), the Greek and Portuguese markets are not as liquid as the other observed markets. However, as illustrated by Fakhry et al. (2016), certainly the asymmetrical effect had the impact of raising the levels of sensitivity to shocks in all the observed markets.

The β coefficients hint at a low level of volatility persistence in the observed markets during the financial crisis. This is to be expected since during the financial crisis, the financial market experienced a constant flight to safety and the US and German markets are regarded as the safe havens. In contrast the GIPS nations were not only perceived to be of a lower quality or liquid but also due to the German market being the key market in the Eurozone. Not surprisingly during the financial crisis as illustrated by Fakhry et al. (2016), the asymmetrical effect had the impact of rising the β coefficients of all the observed markets and hence the levels of persistence in the markets.

The EMH test statistics resultsinnot rejecting the null hypothesis of the market, being too volatile to be efficient in all the observed markets. With the exception of the Portuguese market, the EMH test statistics are significantly greater than the F-statistic. As explained in Fakhry et al. (2016*)*, during the financial crisis market participants were engaging in flights to liquidity or quality meaning that prices were trending upwards faster than the fundamental value. As Fakhry et al. (2016) hints, the inclusion of the asymmetrical effect did not have a significant impact on the EMH test statistics.

Sovereign debt crisis period (02/11/2009-30/12/2011)

Table 3 are associated with the Eurozone sovereign debt and US fiscal cliff crises. Essentially, the sovereign debt crises was the product of the governments providing much needed capital for the banking system and following a fiscal stimulus policy to support the economy after the financial crisis. This added a substantial amount to an already large total debt. However, as previously explained an influencing factor to bear in mind is the maturity effect. Another influencing factor is in order to provide liquidity and boost the economy, many central banks embarked on a quantitative easing policy; this helped maintain the artificially high prices and more importantly low yields in some markets.

The asymmetrical coefficients are indicating a leverage effect during the period accounting for the sovereign debt crisis. With the exception of the Greek market, the evidence seems to be pointing at a significant leverage effect. Interestingly, the asymmetrical coefficient of the Greek market is insignificantly low considering the Greek sovereign debt crisis. As highlighted on numerous times previously, the size and liquidity of the Greek market may provide a partial explanation. However, the asymmetrical coefficients for the remaining observed markets hint at a mixed picture with the Portuguese and Spanish markets hinting at a highly significant leverage effect. The argument is as discussed earlier; the Portuguese market is of a similar in size and liquidity to the Greek market and therefore should response to events in similar fashion. The answer probably lays in the timing of the crises in both markets while the Greek crisis occurred at the start of the subsample period, the impact of the crisis did not spread to the Portuguese market until mid-2010. It is worth noting that the price of the Portuguese bond was not consistently below 100 until end of March 2011 while the price of the Greek bond was consistently below 100 from the end of January 2010. Another key factor is since for the asymmetrical coefficient to be insignificant, the market has to be indifferent between the positive and negative impact. This is the key issue underpinning the Greek market over the duration of this period; the impact on the volatility from the Greek crisis was short and had sharp negative and positive impacts. Although a hike in volatility affected the Portuguese market, it was not as sharp and short as the Greek market; hence, the estimated GJR-GARCH model was able to observe a high leverage effect in the Portuguese market. However, another key explanation as to the significant of the asymmetrical coefficient in the Portuguese market is in the estimation model, due to an error in the estimation we had to use the BHHH optimization. This had a bigger impact on the asymmetrical coefficient.

Table 3. *EMH Test Statistics (02/11/2009-30/12/2011)*

	Greek	Italian	Portuguese	Spanish
Mean Equation	0.034489	0.002517	0.005097	0.003162
a	(0.100328)	(4.29E-05)	(0.000137)	(8.54E-05)
b	0.982734	0.969560	0.984177	0.999832
	(0.004985)	(0.001634)	(0.000865)	(0.001766)
u	1.138810	0.829390	0.745970	0.836750
	(0.038076)	(0.012387)	(0.012060)	(0.012703)
Variance Equation	0.697604	1.46E-07	4.42E-07	5.17E-07
ω	(0.104858)	(3.20E-08)	(2.02E-07)	(1.55E-07)
α	0.711551	2.093871	2.195565	2.775620
	(0.179001)	(0.318346)	(0.236310)	(0.592585)
β	-0.00614	0.055148	0.267627	0.094363
	(0.000157)	(0.026693)	(0.014937)	(0.024345)
γ	-0.02664	-0.50411	-0.95724	-1.00184
	(0.256421)	(0.423612)	(0.285304)	(0.551071)
Statistics Log Likelihood	-581.148	2732.289	1230.006	2080.447
R^2	0.985480	0.983567	0.986223	0.984275
Durbin-Watson	0.529406	0.414409	0.360457	0.405921
ARCH Effect	110.0445	5.560962	7.049023	0.131579
Jarque=Bera	1069.557	143.1955	212.1249	238.6358
Std. Deviation	11.48550	0.064861	1.517370	0.190863
EMH Test Statistics	-0.02797	9.942986	0.333442	4.548493
Efficiency	Accept	Reject	Accept	Reject

The interesting factor is the significantly low α coefficient of the Greek market, which seems to be contradicting Fakhry *et al.* (2016). The Greek α coefficient seems to be suggesting the lowest level of sensitivity to market shocks observed in both models thru all observations. The other key statistics observed in the Greek market provide a clue, which seem to be pointing at an insignificant impact throughout. Hence, the impact from the inclusion of the asymmetrical effect seems to have rendered all coefficients of the Greek market insignificant during the sovereign debt crisis.

The "α" coefficients reflect the diverse impacts of the sovereign debt crisis on the observed markets. The significant α coefficient of the Spanish market issuggesting a high level of sensitivity to market shocks. Although the Spanish market did not feel the impact of the sovereign debt crisis until the later parts, yet a combination of a weakening economy, continuation of the financial crisis and weak local government finance at a time when the spotlight was on government spending did make the Spanish market highly sensitivity to market shocks. Even before the financial crisis, the Italian debt to GDP ratio was the highest in the Eurozone, hence with such a high ratio the Italian market was highly sensitive to market shocks. Although the α coefficients of the Portuguese market were high, however they are not that high. As previously suggested, a possible explanation is size and liquidity of the market. Another explanation is the quick reaction of the Portuguese government, IMF and European Community to the Portuguese crisis. As illustrated by Fakhry et al. (2016), the asymmetrical effect did have an impact on the α coefficients for the markets raising the levels of sensitivity to market shocks.

Since all the coefficients of the Greek market rendered insignificant by the GJR-GARCH model, the "β" coefficients for the remaining observed markets paint a rather mixed picture. While the Portuguese market seems to be suggesting a high level of persistence in the market, the Italian and Spanish markets are hinting at insignificant β coefficients.

Interestingly this means that three of the four GIPS markets have insignificant levels of persistence. As illustrated by Fakhry *et al.* (2016), with the exception of the Spanish market, the inclusion of the asymmetrical effect seems to have increased the volatility persistence of the observed markets in the aftermath of a shock.

As suggested in Fakhry *et al.* (2016), the fundamentals of the sovereign debt markets were already highlighting many issues such as high longer-term unemployment and high debt/deficit in the GIPS countries. However, during any crisis, human nature dictates that market participants react to events rather than the fundamentals of the asset. This is the key to understanding the significant acceptance of the null hypothesis of the markets being too volatile to be efficient with regard to the Italian and Spanish markets. During the early stages of the sovereign debt crisis, these markets were seen as risk free and liquid markets, hence the upwards trend continued making them more predictable. However, of greater interest is the Greek and Portuguese markets acceptance of the efficient market hypothesis, even though the Greek coefficients are not reliable. A possible explanation is that market participants had no option other than to accept the price as given by the fundamentals because the market was no longer dictating the price. In other words, the market participants were increasingly reacting to the fundamental information rather than events, which especially in the case of Greece shows that market participants obviously were not aware or did not take into account the reliability of the Greek national accounts. Although the inclusion of the asymmetrical effect did not have an impact on the resulting efficiency of the market, however it did decrease the EMH test statistics as pointed by Fakhry *et al.* (2016).

Conclusion

In this paper, we introduced an asymmetrical volatility test to analyse the efficiency of the market during different periods. In order to analyse the impact of the asymmetrical effect on the efficiency of the market, we extended Fakhry & Richter (2015) in using a GJR-GARCH. We estimated the excess volatility in the GIPS sovereign debtmarkets, in a fast changing environment encompassing fixed periods of high and low volatility. By using daily data, we had enough degrees of freedom to create subsamples where we could test each subsample individually. The aim was to find out how the 2008 financial crisis and 2009 sovereign debt crisis may or may not have changed the efficiency of the financial markets.

To summarise, the results from our asymmetrical volatility test indicatethat the asymmetrical effect has an impact on the EMH test statistics. In comparison to the results in Fakhry *et al.* (2016), the EMH test statistics appear to have increased in general. This meant that with the exception of the Spanish market that was already efficient, the other marketsare now accepting the efficient market hypothesis during the pre-crisis period. However, both the financial and sovereign debt crisis periods did reflect the efficiency status of Fakhry *et al.* (2016).

A relevant factor raised by our empirical evidence 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. This is what seems to have happened during these periods as market participants reacted to the information and news.

Following Fakhry & Richter (2015) and Fakhry et al. (2016), a key finding in the evidence is the reaction of the market participants depend on the observed periods. Thus meaning market participants' reactions could be reflecting the general market environment. Therefore, hinting at possible regime switching in the reaction of market participants.

Therefore, future research may involve usinsg a switching GARCH model to analyse the impact of high and low volatility on the efficiency of the market. The second is as proposed in the introduction to use an index of the sovereign debt market to better analyse and compare the markets. An advantage with the use of an index is that it has a longer period of observation, this means we analyse the impact of the Euro on the efficiency of the GIPS sovereign debt markets.

It is clear that market participants were acting under uncertainty and lack of full information. Therefore, the results back the conclusions of Fakhry & Richter (2015) and Fakhry *et al.* (2016) in that it is more appropriate speak of bounded rationality than irrationality. Thus further confirming that financial markets are not as efficient as assumed, especially in the neoclassical theory.

References

Alexander, C. (2008). Introduction to GARCH Models, *in* Market Risk Analysis, Vol. 2: Practical Financial Econometrics, C. Alexander (Edt), John Wiley & Sons Ltd, pp.131-199.

Ball, R. (2009), The global financial crisis and the efficient market hypothesis: What have WE learnt?, *Journal of Applied Corporate Finance*, 21(4), 8-16. doi. 10.1111/j.1745-6622.2009.00246.x

Black, F. (1976). Studies of stock market volatility changes, *Proceedings of the Business and Economic Statistics Section*, American Statistical Association pp. 177–181.

Bollerslev, T. & Hodrick, R.J. (1992). Financial Market Efficiency Tests, *NBER, Working Paper* No. 4108. doi. 10.3386/w4108

Cajueiro, D.O., Gogas, P., & Tabak, B.M. (2009). Does financial market liberalization increase the degree of market efficiency? The case of the Athens stock exchange, *International Review of Financial Analysis*, 18(1-2), 50–57. doi. 10.1016/j.irfa.2008.11.004

Cuthbertson, K., & Hyde, S. (2002), Excess volatility and efficiency in French and German stock markets, *Economic Modelling*, 19(3), 399-418. doi. 10.1016/S0264-9993(01)00069-4

Dungey, M., McKenzie, M., & Tambakis, D.N. (2009). Flight-to-quality and asymmetric volatility responses in US treasuries, *Global Finance Journal*, 19(3), 252-267. doi. 10.1016/j.gfj.2008.09.008

Engle, R.F., & Patton, A.J. (2001). What good is a volatility model?, *Quantitative Finance*, 1(2), 237-245. doi. 10.1016/B978-075066942-9.50004-2

Fakhry, B., & Richter, C. (2015). Is the sovereign debt market efficient? Evidence from the US and German Sovereign Debt Markets, *International Economics and Economic Policy*, 12(3), 339-357. doi. 10.1007/s10368-014-0304-9

Fakhry, B., Masood, O., & Bellalah, M. (2016). The efficiency of the GIPS sovereign debt markets during the Crisis, *International Journal of Business*, 21(1), 87-98.

Fama, E.F. (1965). Random walks in stock market prices, *Financial Analyst Journal*, 21(5), 55-59. doi. 10.2469/faj.v21.n5.55

Fama, E.F. (1970). Efficient capital markets: A review of theory and empirical work, *The Journal of Finance*, 25(2), 383-417. doi. 10.2307/2325486

Fama, E.F. (1991). Efficient capital markets: II, *The Journal of Finance*, 46(5), 1575-1617. doi. 10.1111/j.1540-6261.1991.tb04636.x

Glosten, L.R., Jagannathan, R., & Runkle, D.E. (1993). On the relation between the expected value and the volatility of the nominal excess returns on stocks, *Journal of Finance*, 48(5), 1779-1801. doi. 10.1111/j.1540-6261.1993.tb05128.x

Kirchler, M. (2009). Underreaction to fundamental information and asymmetry in mispricing between bullish and bearish markets. An experimental study, *Journal of Economic Dynamics and Control*, 33(2), 491-506. doi. 10.1016/j.jedc.2008.08.002

LeRoy, S.F. (1989). Efficient capital markets and martingales, *Journal of Economic Literature*, 27(4), 1583-1621.

LeRoy, S.F., & Porter, R.D. (1981). The present-value relation: Tests based on implied variance bounds, Econometrica, 49(3), 555-574. doi. 10.2307/1911512

Lo, A.W., & MacKinlay, C. (1988). Stock market prices do not follow random walks: Evidence from a simple specification test, *The Review of Financial Studies*, 1(1), 41-66. doi. 10.1093/rfs/1.1.41

Malkiel, B.G. (1962). Expectations, bond prices, and the term structure of interest rates, *The Quarterly Journal of Economics*, 76(2), 197-218. doi. 10.2307/1880816

Metiu, N. (2011). The EMU in debt bistress: Contagion in sovereign bond market, European Economic Association & Econometric Society 2011 Parallel Meetings, Oslo, 25-29 August 2011

Mohl, P., & Sondermann, D. (2013). Has political communication during the crisis impacted sovereign bond spreads in the euro area?, *Applied Economics Letters*, 20(1), 48-61. doi. 10.1080/13504851.2012.674201

Nelson, D.B. (1991), Conditional heteroscedasticity in asset returns: A new approach, *Econometrica*, 59(2), 347-370. doi. 10.2307/2938260

Shiller, R.J. (1979). The volatility of long-term interest rates and expectations models of the term structure, *The Journal of Political Economy*, 87(6), 1190-1219. doi. 10.1086/260832

Shiller, R.J. (1981a). The use of volatility measures in assessing market efficiency, *The Journal of Finance*, 36(2), 291-304. doi. 10.1111/j.1540-6261.1981.tb00441.x

Shiller, R.J. (1981b). Do stock prices move too much to be justified by subsequent changes in dividends?, *The American Economic Review*, 71(3), 421-436.

Shiller, R.J. (1992). *Market Volatility*, Cambridge (Massachusetts): MIT Press

Tamakoshi, G. (2011). European sovereign debt crisis and linkage of long-term government bond yields, *Economic Bulletin*, 31(3), 2191-2203.

Zakoian, J.M. (1994). Threshold heteroskedastic models, *Journal of Economic Dynamics and Controls*, 18(5), 931-955. doi. 10.1016/0165-1889(94)90039-6

Zunino, L., Bariviera, A.F., Guercio, M.B., Martinez, L.B., & Rosso, O.A. (2012). On the efficiency of sovereign bond markets, *Physica A*, 391(18), 4342-4349. doi. 10.1016/j.physa.2012.04.009

4 Does the federal constitutional court ruling mean the German financial market is efficient?

Introduction

The question of what moves prices in the financial market is in itself not a new one. Recently, this debate gained new ground due to the recent financial crises which started in mid-2007. Therefore, the landmark ruling by the German Federal Constitutional Court in Karlsruhe on 7th February 2014 in which they endorsed the efficient market hypothesis per Winkler (2014) is interesting on many levels. In a way, this highlights the question does the ruling mean that the German financial market is efficient? Furthermore, it raises an issue if the efficient market hypothesis is the key explanation of the price movement in the financial market then are the criticisms, as noted by Ball (2009) and Fakhry (2016), in the aftermath of the crises justified? The main question of what moves financial markets is important for researchers in the field of applied finance and portfolio manager, due to it being the underlining factor in investment decisions and portfolio optimisation. One of the key reasoning is that it is crucial for market par- ticipants wanting alphas for their investments decisions and portfolio optimisations.

Perhaps an explanation of the efficient market hypothesis or EMH would be ideal at this point. The EMH was developed thru the contribution of prominence articles by Fama & Malkiel such as: Malkiel (1962), Fama (1965), Malkiel & Fama (1970). At the basic level, the EMH hypothesize, as proposed by Malkiel (1962) and Fama (1965), that the price of any asset must immediately reflect fundamental information regarding the asset. The assumption is that market participants behave in accordance with the theory of perfect competition which is based on an idealise world where market participants are rational, risk averse and profit maximisers. Of course, recent events have illustrated that this is not always the case as Ball (2009) and Fakhry (2018) have shown. Therefore, there is a need to include behavioural finance in the pricing of any asset. The key argument underpinning behavioural finance is as put so elegantly by Thaler (2015, p.4) market participants are homo sapiens and not homo economicus, hence as stated by Bernard Baruch: "What is important in market fluctuations are not the events themselves, but the human reactions to the events" (Lee *et al.,* 2002).

A key factor in the efficiency of the market is the differentiation between long and short run price volatility behaviour. As suggested by De Bondt (2000), the price tends to deviate from the fundamental value in the short run. However, the price usually reverts to the fundamental value in the long run. This is more obvious during an asset price bubble; as hinted by Blanchard & Watson (1982) and Barlevy (2007). Essentially an asset price bubble is a rapid upwards pressure on the price, eventually causing systematic downwards pressure to correct the price. Often leading to a crash in the prices where the price is under massive downwards pressure. In the long run, the market could return to the fundamental price and hence be "efficient" or it could collapse. The price movements are driven by market participants' reaction to events and information which differ and may be asymmetric in the short-run and long-run.

In order to analyse the different impacts from the short and long run on the efficiency of the German financial market, we change the variance bound tests of Fakhry & Richter (2015, 2016a, 2016b) and Fakhry *et al.* (2017) to use an asymmetrical variant of the C-GARCH model proposed by Engel & Lee (1999). This will allow us to distinguish between the long and short run efficiency. We also contribute by using the Euro currency index and German All Maturity sovereign debt index obtained from the Bank of England and Barclays Bank plc respectively. In addition, we use the DAX stock index. Since Germany has the second largest gold reserve and is the fourth biggest consumer of gold according to the World Gold Council, we also use the Euro gold index obtained from the World Gold Council.

Our findings indicate that unlike previous studies conducted using the variance bound test e.g. Fakhry & Richter (2015, 2016a), we found evidence suggesting that the German financial market is efficient. All four observed German markets: equity, gold, sovereign debt and foreign exchange were efficient in both the long and short runs. This suggests that the differentiation between the short and long run is limited in the case of the German financial market. However, another possible explanation is the stability state argument of Fakhry (2016). Fakhry (2016) hints that during large observations containing both high and low volatile periods, the periods could cancel each other out leading to the market appearing to be stable and efficient. This is usually the case in the long run as argued by De Bondt (2000). However, as argued Engle & Lee (1999), in the short run the market is more volatile and reactive; thus should reflect an inefficient market. There is a clue in the previous statement, a reactive market can sometime lead to a false state of stability which gives the impression of an efficient market, especially over a long period of observation.

Our two key contributions is that we use the component GARCH-T to analyse the long and short run efficiency of the market. Thus leading to our main contribution, namely that the results defy the conventional wisdom in that we found that the German financial market seems to be efficient in both the long and short runs.

Furthermore we also contribute via the data we use. although previously many have used stock and FX indices to observe the efficiency of the financial markets, yet the use of sovereign debt and gold market indices has been limited in the area of financial econometrics in general. The second contribution is that we analyse the efficiency of the Euro currency index as obtained from the Bank of England which have also been limited.

This article is structured in the following way. Firstly, we will briefly and critically review the recent empirical literature on the EMH, behavioural finance theory and component GARCH model. This will lead to the methodology which will describe specification of the variance bound test and underlying asymmetrical component GARCH models. Sections four and five presents the data and empirical results. Finally, section 6 concludes.

Literature review

The Literature review is divided into three key subsections: a review of the empirical evident on the EMH, behavioural finance theory and the Component GARCH model. This article will not review the theories and tests underpinning the EMH and behavioural finance theory, see Fakhry (2016) and Fakhry (2018) for a critical review of the theories and tests. The crucial factor is the differentiation of the long run and short run on the price volatility which impact the efficiency of the market.

Review of the efficiency of the markets

The empirical evidence of the past few years have illustrated that markets are not efficient during a period of highly volatile and reactive environment as highlighted by recent studies in the sovereign debt market by Fakhry & Richter. In a series of studies into the efficiency of the sovereign debt market, see Fakhry & Richter (2015, 2016a, 2016b), they found that in general market participants reacted to events rather than fundamental information during the recent financial and sovereign debt crises. A similar point was illustrated by Fakhry *et al.* (2017). However, these studies also highlighted some evidence of efficiency during several periods in several markets. Conversely, although Fakhry & Richter (2015, 2016a) provided mixed evidence of the efficiency of the German Bund market. In truth, the evidence was pointing to an inefficient market in the general sense; since in theory any market cannot be partly efficient.

The evidence in the stock market is also mixed as illustrated by several recent studies (i.e. Borges, 2010; Panagiotidis, 2010; Onali & Goddard, 2011; Todea & Lazar, 2012; Sensoy & Tabak, 2015; Singh *et al.*, 2015). Conversely, Borges (2010) found a split in the European stock markets with the Greek and Portuguese rejecting and the western European countries including Spain accepting the weak form EMH. Also finding that the German market does accept the weak form of the EMH. Interestingly, Sensoy & Tabak (2015) study- ing the impact of long-time memory on the efficiency of the European Union stock markets during the recent financial and sovereign debt crises found mixed evidence. This seem to be backing the evidence found in the sovereign debt market by Fakhry & Richter (2015, 2016a, 2016b) and Fakhry *et al.* (2017).

In a way, the recent evidence on the efficiency of the FX market is similar to the previous two markets in that it is mixed see (Ahmad *et al.*, 2012; Lee & Sodoikhuu, 2012; Boboc & Dinică, 2013; Mele, 2015). Lee & Sodoikhuu (2012) analysed the impact of market strategies on the efficiency of the FX Market, finding that in general the three observed FX markets are efficient. Conversely, transaction costs do have a greater impact on the efficiency of the FX market. A key finding in accordance with our article is that the euro/dollar FX rate is efficient. Mele (2015) find that arbitrage opportunities do exist for longer periods in the FX market, therefore violating one of the fundamental rules underpinning the EMH: arbitrage opportunities don't exist for long periods. By default, this means that the FX market is inefficient. The results conflict with that of Lee & Sodoikhuu (2012) in illustrating that the leading FX markets, including the Euro, are inefficient.

Like the other markets, the limited recent empirical evidence for the efficiency of the gold market seem to be hinting at an inefficient market. Although the empirical evidence is not direct testing the EMH, the literature is concentrating on a weak form of efficiency by using two methods. The first is cointegration as use in Narayan *et al.* (2010) and Zhang & Wei (2010), the argument is if the market has a cointegration relationship with other markets than the market is regarded as inefficient. Narayan *et al.* (2010) found that the gold market has a cointegration relationship with the oil market. Zhang & Wei (2010) also found a strong relationship between the gold and oil markets. The second is multifractal as use in Wang *et al.* (2011), the argument is that if the trend in the market is unexplained by a single factor then the market is regarded as inefficient. However, Wang *et al.* (2011) seem to be hinting at a rather mixed evidence with the gold market appearing to be efficient during upward trending periods and inefficient during downward trending periods. Mali & Mukhopadhyay (2014) provide further evidence of the multifractal nature of the gold market in the Indian, Chinese and Turkish markets there- fore these markets are regarded as inefficient.

Brief review of the alternative theory of asset pricing: Behavioural finance

As we have seen the recent empirical evidence on the efficiency of the market is not strong, Hence there is a need to include the behavioural finance theory for a complete picture of financial asset pricing. So we will analyse the empirical evidence on key behavioural factors in recent years.

In studies by Fakhry *et al.* (2017) and Masood *et al.* (2018), they found evidence of overreacting in the sovereign debt market. The Greek market is relatively small in comparison with the size of the eurozone market, hence the Eurozone crisis was based on overreacting market participants. Also as hinted by Fakhry (2018), during the financial crisis market par- ticipants fleeing from the equity markets and mortgage backed securities were underreacting in the sovereign debt market, there is a pattern of behaviour during any flight top safety that tend to lead to an underreaction. Conversely, as Ball (2009) points out there was a hint of underreaction to the information underpinning the mortgage back securities during the asset bubble of the mid-2000s.

Analysing the impact of the Tohoku Tsunami of 2011 on the Japanese financial market, Fakhry *et al.* (2017) found overreaction in the equity, FX and sovereign debt market during the immediate aftermath. This is in line with previous studies like Maierhofer (2011), Luo (2012), Parker & Steenkamp (2012) and Ferreira & Karali (2015) who found no impact other than in the immediate aftermath. Thus hinting that an overreaction is nearly always short lived during extreme events.

Another behavioural factor often observed is herding, Nofsinger & Sias (1999) character- ized this phenomena as trading in the same direction by a group of investors for a period of time. This is often the case during in extreme conditions such as bubbles as illustrated by Jiang *et al.* (2010), Sornette & Cauwels (2015) and Gerlach *et al.* (2018) and crashes as highlighted by Brunnermeier (2009) and Economou *et al.* (2011) during flights.

Review of long/short run volatility

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. This means that the factors effecting the price and hence price volatility in the short and long runs are different. 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). In this section, we will review the empirical evidence on the C-GARCH model.

Recent empirical evident for the C-GARCH model seem to agree with the general con- ception that financial market volatility differ- entiate between long and short runs. Much of the literature is concern with the volatility in the stock market. Guo & Neely (2006) found evident consistent with Engle & Lee (1999) suggesting that long-run volatility better determines the international conditional equity premium than the short run volatility. Adrian & Rosenberg (2008) interprets the short- run volatility component as a measure of financial constraints tightness, while the long run volatility component is related to business cycle risks. However contrary to the accepted wisdom, Pastor & Stambaugh (2012) found that in accounting for predictor imperfection stock markets are more volatile in the long run. Du & Hu (2014) analysing the impact of the long run component in FX volatility on the stock market returns found that it does have explanatory power in determining the stock returns.

Analysing the Eurozone sovereign debt market, Sosvilla-Rivero & Morales-Zumaquero (2012) found a different between both volatility components. In general, the permanent compo- nent exhibited long memory while the transi- tory component exhibited short memory. They highlight that shocks are of higher importance than transitory shifts in the Eurozone sovereign debt market. Furthermore, they hint at a familiar split between the core and peripheral Eurozone countries in the transitory shifts with respect to the degree of policymakers' credibility and public finance's stability.

Methodology

The main aim of this paper is to extend the variance bound test of Fakhry & Richter (2015) and Fakhry & Richter (2016a) to analyse the efficiency of the markets in the long and short runs. We proposed a new variance bound test by extending Fakhry & Richter (2016a) using an asymmetrical C-GARCH, proposed by Engle & Lee (1999), variant of the variance bound test proposed by Shiller (1979, 1981). We use the 5% critical value F-statistics to test the efficient market hypothesis. As with Fakhry & Richter (2015, 2016a, 2016b) and Fakhry *et al.* (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).

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

2. The first order autoregressive model estimates the residuals in the econometric model underpinning the test as illustrated by equation 2 and 3:

$$var(Price_t) = a + b_1 var(Price_{t-1}) + u_t \quad (2)$$
$$u_t = \tau u_{t-1} + \epsilon_t \quad (3)$$

3. Estimate the first order asymmetrical C- GARCH (1, 1) model to obtain the long run and short run volatility coefficients. It is worth remembering that the GARC (p,q) model as proposed by Bollerslev (1986) is written as equation 4 where

$$h_j = \omega + \alpha_{\mathrm{p}} k_{t-1} + \beta_{\mathrm{q}} h_{t-1} \tag{4}$$

As suggested by Engle & Lee (1999), equation 4 can be slightly transformed into equation 5 where the dynamics of the structure of conditional variance can be illustrated:

$$h_{jt} = \sigma 2 + (\alpha_{\mathrm{p}} k_{t-1} - \sigma 2) + \beta_{\mathrm{p}} h_{t-1} - \sigma 2 \tag{5}$$

The issue is that σ^2 represents the uncon- ditional 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 lowly 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 equation 6 whereby σ^2 is represented by mt, a time varying long run model of volatility.

$$m_t = \omega + \rho_{\mathrm{p}} m_{t-1} + \varphi_{\mathrm{q}} (k_{t-1} - h_{t-1}) \tag{6}$$

$$(h_t - m_t) = \sigma 2 + (\alpha_{\mathrm{p}} k_{t-1} - m_{t-1}) + (\beta_{\mathrm{q}} h_{t-1} - m_{t-1}) \tag{7}$$

Hence, equation 6 is a stochastic representatives of the long run volatility otherwise known as the trend in volatility and equation 7 is the difference between the conditional volatility and trend, i.e. the long run volatility. Essentially equation 7 is the short run or transitory volatility.

In essence, this means the dynamics of the volatility components can be interpreted as in 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 $0 < \varrho < 1$ then it will converge to a constant level of $\frac{\omega}{1-\rho}$.

The third step is based on the assumption1−tϱhat 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 $0 < (\alpha + \beta) < \varrho < 1$.

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 7. The TARCH model as defned by Zakoian (1994) is given by equation 8. Taking equation 8, 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 9. Notice how if the asymmetrical effect is zero the basic model collapses to a CGARCH model as illustrated by equation 7. A key factor is that the asymmetrical effect is only added to the short run component of the C-GARCH model, see equation 9. This is mainly due to the short life of the asymmetrical effect.

$$h_t = \alpha k_{t-1} + \beta \quad h_{t-1} + \gamma \quad k_{t-1} I \tag{8}$$

$$(h_t - m_t) = \sigma 2 + (\alpha_{\text{p}} k_{t-1} - m_{t-1}) + (\beta_{\text{q}} h_{t-1} - m_{t-1}) + \gamma(k_{t-1} - m_{t-1})\text{I} \tag{9}$$

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

As with Fakhry & Richter (2016a, 2016b), we also illustrate the impact of the asymmetrical effect on the Efficiency of the market. The key is the γ coefficient in equation 9 where $\gamma \neq 0$ then there is an asymmetrical effect; if $\gamma > 0$ 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 the transitory and permanent variance 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 EMH test by using the fstatistics; for our observed samples, the fstatistics at the 5% level is 1.96. We calculate our test statistics using equation 10 and 11 as the short run and long run tests of Efficiency respectively.

$$EMH\ Test_{SR} = \frac{(\alpha+\beta+\gamma)-1}{standard\ \ deviation\ \left(var\,(x)\right)} \leq Fstatistics \qquad (10)$$

$$EMH\ Test_{LR} = \frac{(\rho+\varphi)-1}{standard\ \ deviation\ \left(var\,(x)\right)} \leq Fstatistics \qquad (11)$$

By defnition the market is efficient when the conditions as set in equations 10 and 11 are true. Theoretically, the market is only truly efficient when the EMH test statistics is equal to the f-statistic. Hence, we reject the null hypothesis for the EMH if the condition in equations are true but accept the null hypothesis of the market being too volatile to be efficient for anything else.

Data description

As stated previously, this paper analyses the three major German fnancial markets to establish whether the court ruling means they are efficient. With this in mind, we test the Efficiency of the equity, FX and sovereign debt markets. As illustrated in, we opt to use the price on indices to reflect the German fnancial market. As with the norm, we choose to use a fve-day week flling in the missing data with the last known price.

It must be noted that similar to all indices the four indices are based on weighted ratios of the components prices. The DAX consist of thirty of the largest listed companies on the German equity market each weighted by a given ratio. The Euro Currency Index1 is calculated on a daily basis by the Bank of England using the fve major currencies with a weighted ratio: US Dollar, British Sterling, Japanese Yen, Swiss Franc and Swedish Krona. As hinted by the name, the German All Maturities GovernmentIndex consists of all the government bonds maturities weighted by a ratio. The Gold Price Index consist of all gold markets in the Eurozone indexed to 1st January 1999.

A key issue with our variance bound test was the standard deviation of the DAX Index and Gold market variances which caused a problem with the EMH test statistics. We tried several methods to resolve the issue, the best solution was to divide the daily index price by 100 and 10 for the DAX and Gold prices respectively before calculating the fve-day variance.

Empirical evidence

As hinted earlier, the keys to the EMH 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.* (2017), the estimated model was the GARCH. In Fakhry & Richter (2016a, 2016b), the model used was the GJRGARCH. The GJR-GARCH had the influential factor of allowing for the analysis of the asymmetrical effect on the EMH. We continue to use the asymmetrical effect in this paper, however we also analyse the effect of long and short runs on EMH. For this reason, we use the C-GARCH with an asymmetrical factor in the estimation of the coefficients. We test for overall, long run and short run Efficiency. We also analyse the behaviour of the German fnancial market volatility.

Tablo 2. *Model settings*

Option	Setting
Optimisation Method	EViews Legacy
Legacy Method	Marquandt
Max Iterations	5,000
Convergence	0.0001
CoEfficient Covariance Method	Ordinary
Starting CoEfficient Values	EViews Supplied
Presample Variance	Backcast with parameter = 0.7
Derivative Method	Accuracy

In estimating the models, we used the settings in Tab. 2. However, with the error distribution, we used a different distribution model for each dataset to get the best estimation: Equity (Normal), FX (GED), Sovereign Debt (Student's *t*) and Gold (Student's *t*). Crucially, the system environment may influence the estimation: Our system is running EViews 9.5 on a Windows 10 Pro, 6 cores CPU and 24 Gigabytes RAM computer2.

A general summarization is the observation of a different in the behaviour of price volatility between the long and short runs in all three fnancial markets. It is to be noted that the volatility seems to be more persistence in the long run than the short run. However as argued by De Bondt (2000), the evidence seem to suggest that the market is reverting back to the fundamental value in the long run. A key explanation is persistency in market volatility can only be observed in the long-run, since the persistent is based on long memory behaviour as hinted by Engle & Lee (1999). However, the markets seem to be highly reactive in the short run. This appears to be in accordance with the accepted wisdom of volatility being greater in the short run than the long run as argued by Engle & Lee (1999) and Pastor &

Stambaugh (2012). This is to be expected, since behavioural theories dictate that market participants react with greater intensity to news in the short run as hinted by Engle & Lee (1999). In effect this means that the effect of the reaction of the German market participants on fnancial market volatility is deviating with time as suggested by Engle & Lee (1999), De Bondt (2000) and Pastor & Stambaugh (2012).

Table 1. *Major German financial markets indices*

Market	Equity	Foreign exchange	Sovereign	Gold
Index	DAX	Effective Exchange Rate Index, Euro	German all Maturities Index	Gold Price Index, Euro
Source	Investing.com	Bank of England	Barclay Risk Analytics & Index Solutions Ltd.∗)	World Gold Council
Period	from 02/01/1981 to 31/12/2016	from 02/01/1975 to 31/12/2016	from 02/01/1997 to 31/12/2016	from 29/12/1978 to 31/12/2016
Observations	6,783	10,957	4,958	9,916

Note: ∗) It must be noted that on the 24th August 2016 the Barclay Risk Analytics and Index Solutions Ltd. was taken over by Bloomberg. So, the product is now known as Bloomberg Government bonds.

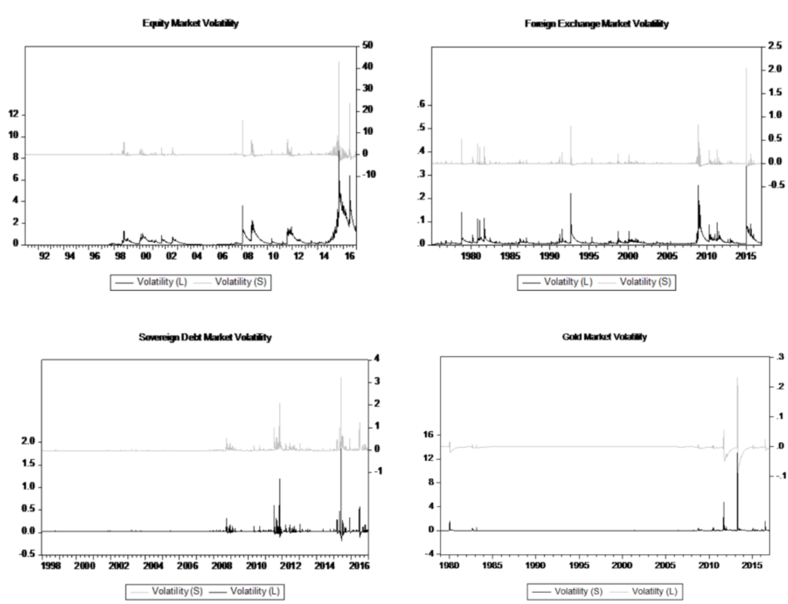


Figure 1. *German Financial Markets Volatility Components*

The observed period is interesting because it highlights the different impact of major events on the long and short run volatility. Essentially, Fig. 1 highlights the impact from two key events on the German fnancial market, fnancial crises of late 2007 to 2016. Whichever way you look at it, the fnancial crises seem to have a strong effect on the three observed markets. Conversely, the Brexit vote on 23rd June 2016 extended the volatile period. Of cause the introduction of the Euro on 1st January 1999 is of signifcant interest to the German fnancial market, yet the evident from Fig. 1 seem to hint at a slight impact on the equity and FX markets but none on the sovereign debt and gold markets.

However, it is worth remembering that these two markets are regarded as safe havens and the introduction of the euro was not regarded as a risk. Another possible explanation is due to the large impact of the fnancial and sovereign debt crises on these two markets, the volatility in these two markets deviated away. Remember a key theory of the GARCH/ARCH models as intended by Engle (1982) and Bollerslev (1986) is that volatility deviates over time, so a highly volatile event in the past becomes less influential with time on the observed dataset.

The other major event is the aftermath of the re-unifcation of Germany in 1990 which seem to be highlighted in the FX market but not in the equity and gold markets. However, a key factor during that period could be the impact from Black Wednesday on 16th September 1992 and the effect it had on the European Exchange Rate Mechanism (ERM). The high ϱ coefficients in Tab. 2 seem to be indicating the presence of highly persistent permanent volatility in the equity and FX markets. On close inspection of Fig. 1, the reasoning becomes clear, both markets were at the heart of periods of constant highly volatile environment as illustrated in the previous paragraph. Market participants are highly reactive to events such as these. The second factor is the long-run effects of the introduction of the Euro and the recent fnancial and sovereign debt crises which contributed to the high persistent of volatility. It would seem that the recent crises were also a relevant contributory for the high persistency in the gold market. Conversely, Fig. 1 also explains the low volatility persistence in the sovereign debt market as illustrated by the ϱ coefficient of the market in Tab. 3. In comparison to the other three observed markets, the sovereign debt market seemed to be relatively stable until the recent crises with only a few minor hikes in volatility. A possible explanation is generally during a period of economic and financial market upturn like the early to mid-2000s, market participants are less reactive and thus market volatility is less persistent. This leads to another explanation, during a period of increasing asset prices, market participants look for high return risky markets, in simple terms acting irrationally leading to a bubbled market. The sovereign debt market is generally regarded as a risk-free low earning market, especially the German market.

As explained earlier, the short run volatility persistent tends to be generally low, a point in case are the observed β coefficients of all four markets in Tab. 3. The coefficients seem to be hinting at very low volatility persistency in all four markets with coefficients of not greater than 0.708. As implied by Engle & Lee (1999), theory dictates over a long-time horizon market shocks tend to decay in ferocity. Thus, meaning that in the long run the effect of any event inducing high market shocks on prices become less relevant. This is observed in the equity, gold and FX markets as illustrated by Tab. 3 with the ϕ coefficients pointing to a lower market shock in the long run. In effect the ϕ coefficients are under 0.1 for all three markets hinting at a low sensitivity to market shocks. As Fig. 1 illustrates, all three markets suffered a signifcant hike in price volatility during the recent crises period plus the Brexit vote and the ff coefficients, greater than 0.2, seem to be reflecting this hike. Mainly due to the timing and severity of a combination of events (i.e. the recent Eurozone sovereign debt crises and Brexit vote) and the German sovereign debt market status as the safe haven and liquid market in the Eurozone, the long run effect of the shocks in the sovereign debt market did not decay away given the time horizon as illustrated by the ϕ coefficient at 0.186334. In the short run, the high ff coefficient of 0.312428 is a sign of the market during the crises period.

A key observation made in Fakhry & Richter (2016a, 2016b) is that the asymmetrical effect has an impact on the Efficiency of the market. As illustrated by Tab. 3, we observed a low γ coefficient for all four markets with absolute value of no greater than 0.09 observed in the gold market. This does mean that there is a limited asymmetrical effect in each of the markets. The equity and gold markets display a negative γ coefficient which means that negative shocks to the market have greater impact than positives shocks in the short run. As hinted by Black (1976), a key observation often made in the equity market is the negative correlation between returns and volatility. The limited leverage effect is a hint of this observation. The key word in there being limited, for an explanation we need to look at the observed German equity and gold markets. It is highly possible that during the period before the onslaught of the recent global fnancial crises, both markets experienced one type of asymmetrical effect. However, the onslaught of the recent global fnancial crises changed the asymmetric effect. The positive and negative effects may have counter-balanced each other, hence leading to the near zero impact. Conversely, due to the timing and ferocity of the negative impact on the markets during the recent global fnancial crises, there is a limited leverage effect. The tworemaining markets point to a limited positive asymmetrical effect hinting at positive shocks to the market having a greater impact than negative shocks in the short run. An explanation for the observations of positive asymmetrical effects could be found in a combination of the global status of both markets and the recent global fnancial environment. This added to the reversed of the combination effect underpinning the explanation of the observed limited leverage effect in the equity and gold markets means that the FX and sovereign debt markets exhibit slight positive asymmetrical effects.

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

$$m_t = \omega + \rho_{\mathrm{p}} m_{t-1} + \varphi_{\mathrm{q}}(k_{t-1} - h_{t-1}) \quad (6)$$

$$(h_t - m_t) = \sigma 2 + \left(\alpha_{\mathrm{p}} k_{t-1} - m_{t-1}\right) + \left(\beta_{\mathrm{q}} h_{t-1} - m_{t-1}\right) + \gamma(k_{t-1} - m_{t-1})\mathrm{I} \quad (9)$$

$$EMH\ Test_{LR} = \frac{\sum \text{coefficients} \ -1}{standard\ \ deviation\ \left(var\,(price\,)\right)} \quad (10, 11)$$

Market	Equity	Foreign Exchange	Sovereign Debt	Gold
Mean Equation				
a	0.071782 (0.002136)	0.009607 (0.000192)	0.020584* (0.000678)	0.005543* (8.41E-06)
b	0.716483 (0.006919)	0.736035 (0.003483)	0.691017 (0.006640)	0.719573 (0.001878)
u	0.507201 (0.013024)	0.306194 (0.006653)	0.377432 (0.015129)	0.375839 (0.000891)
Variance Equation				
ω	7.480590 (0.384085)	0.029847 (0.033685)	0.026859 (0.003366)	-2.37E-05 (2.16E-04)
Long-run Price Volatility				
ϱ	0.999998 (6.42E-08)	0.998977 (0.001167)	0.847473 (0.023697)	0.987450 (9.24E-04)
ϕ	0.039161 (0.000976)	0.087957 (0.022952)	0.186334 (0.022307)	0.008243 (0.002056)
Short-run Price Volatility				
α	0.213435 (0.003626)	0.359580 (0.019467)	0.312428 (0.017036)	0.453493 (0.020139)
γ	-0.019528 (0.005517)	0.359580 (0.019467)	0.012089 (0.001591)	-0.092895 (0.015680)
β	0.707345 (0.005470)	0.577842 (0.025604)	0.675722 (0.017817)	0.646091 (0.008971)

Model Statistics Log Likelihood	1,374.877	20,161.730	7,075.928	28,617.290
R^2	0.719687	0.712889	0.725742	0.751854
Durbin-Watson	2.156971	1.625504	1.575250	1.686794
ARCH Effect	0.339560	0.028096	0.018395	0.526407
Jarque-Bera	434,325.4	22,946,634	491,035.9	3,280,977
σ^2	1.193893	0.166384	0.317139	0.233287
Efficiency Tests Long-run Efficiency				
EMH Statistics	0.032799	0.522490	0.106600	0.018462
Efficiency	Accept	Accept	Accept	Accept
Efficiency Tests Short-run Efficiency				
EMH Statistics	0.082711	0.000343	0.000754	0.028673
Efficiency	Accept	Accept	Accept	Accept

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

A key measure of risk factors in the market is the standard deviation, essentially defned as the dispersion of the observed market prices around the expected market price. The standard deviation statistics from Tab. 3 seem to be hinting at a large dispersion from the expected price variance in the equity market with a σ2 of approximately 1.194. A clue is in Fig. 1, both the long and short run volatilities hint at a large hike in the equity market during the recent fnancial crises which gives the impression of a large dispersion in the equity market. The FX market has a low standard deviation of approximately 0.166, this is to be expected since the euro did not deviate from the expected value by much. Even during the Eurozone crises, the movement against the benchmark currencies was not that great in both the long and short runs, as hinted by Fig. 1. The sovereign debt market suffered from spikes in the volatility during the Eurozone crises which is indicated by the low standard deviation of 0.317 and the level of volatility in Fig. 1. It must be noted that the German sovereign debt market is regarded as the risk-free benchmark market in the Eurozone, so the movement in the market was mainly due to runs in the Eurozone markets leading to upward pressures on the German sovereign debt market. And as the age old saying by Isaac Newton goes: “what goes up must come down” eventually, hence the normalisation of the sovereign debt market towards the fundamental long run value may have also been a factor in the moderate standard deviation. The same could be said about the gold market, remember the gold market is the global safe haven market. In essence, the gold market, similar to many other commodity markets, suffered a bubble reaction during the global fnancial crises. However, the low dispersion is a sign that the impact of the global fnancial crises did not impact the overall observation.

Essentially, our variance bound test is saying that for a market to be efficient it must be efficient in the short and long runs. As illustrated by Tab. 3, the signifcant of the variance bound test is the results seem to be hinting at the acceptance of the EMH in all the observed markets in both the short and long runs. The statistics are damming for behavioural fnance with EMH statistics not greater than 0.6, it must be remembered that these are well within the bound of 1.96.

Conclusion

In this chapter, we extended the work done by Fakhry and Richter in recent years to analyse the Efficiency of the German fnancial market in the short and long runs. We differed from previous work by Fakhry and Richter in using a fve-day variance calculation and the key indices of the German market. We used a Component GARCH including a threshold to obtain the short and long runs' volatility and coefficients for our EMH tests. Our results show that the German fnancial market is efficient in both the short and long runs. The results seem to be a damming rejection of the behavioural fnance theory and an endorsement of the court ruling. However, as is the case with any test there are a number of factors to account for. The frst and foremost is the observational period in all the market, if the period was based around the fnancial and sovereign debt crises then the results may have been different. The second is the volatility model, i.e. Component GARCH, underpinning our volatility tests could be a key factor in the acceptance of the EMH. It would be interesting to see if the German financial market was efficient around the crises period of the late 2000s to early 2010s. Given that the results of Fakhry & Richter (2015, 2016a, 2016b) did found that the German market is generally inefficient during the crisis period.

Our main contribution, the methodology, is relevant in analysing the long and short run Efficiency of the market and therefore making the optimal investment decision be it in an asset or as part of a portfolio. The results of our empirical study are important for researchers in the felds of applied fnance and portfolio management. Additionally, the paper can be useful for portfolio managers and market participants in making investment decisions or portfolio optimisation.

In concluding, the results seem to suggest that the court case was right to endorse the EMH. However, we urge caution on rejecting the behavioural fnance theory due to past empirical evidence suggesting that the German market is not always efficient.

References

Adrian, T., & Rosenberg, J. (2008). Stock returns and volatility: Pricing the short-run and long-run components of market risk. *The Journal of Finance*, 63(6), 2997–3030. doi. 10.1111/j.1540-6261.2008.01419.x

Ahmad, R., Rhee, S.G., & Wong, Y.M. (2012). Foreign exchange market Efficiency under Recent Crises: Asia-Pacific focus. *Journal of International Money and Finance*, 31(6), 1574–1592. doi. 10.1016/j.jimonfin.2012.02.016

Ball, R. (2009). The global financial crisis and the efficient market hypothesis: What have ee learnt? *Journal of Applied Corporate Finance*, 21(4), 8-16. doi. 10.1111/j.1745-6622.2009.00246.x

Barlevy, G. (2007). Economic theory and asset bubbles. *Economic Perspectives*, 31(3), 44–59.

Black, F. (1976). Studies of stock market volatility changes. *In Proceedings of the 1976 Meeting of the Business and Economic Statistics Section*, American Statistical Association, pp.177–181.

Blanchard, O.J. & Watson, M.W. (1982). Bubbles, rational expectations and financial markets. *NBER Working Paper*, No.945. doi. 10.3386/w0945

Boboc, I.-A., & Dinică, M.-C. (2013). An algorithm for testing the efficient market hypothesis. PLoS ONE, 8(10), doi. 10.1371/journal.pone.0078177

Bollerslev, T. (1986). Generalized autoregressive conditional heteroskedasticity. *Journal of Econometrics*, 31(3), 307–327. doi. 10.1016/0304-4076(86)90063-1

Borges, M.R. (2010). Efficient market hypothesis in European stock markets. *The European Journal of Finance*, 16(7), 711–726. doi. 10.1080/1351847X.2010.495477

Brunnermeier, M.K. (2009). Deciphering the liquidity and credit crunch 2007-2008. *The Journal of Economic Perspectives*, 23(1), 77-100. doi. 10.1257/jep.23.1.77

Colacito, R., Engle, R.F., & Ghysels, E. (2011). A component model for dynamic correlations. *Journal of Econometrics*, 164(1), 45–59. doi. 10.1016/j.jeconom.2011.02.013

Du, D., & Hu, O. (2014). The long-run component of foreign exchange volatility and stock returns. *Journal of International*

Financial Markets Institutions and Money, 31(1), 268–284. doi. 10.1016/j.intfin.2014.04.005

De Bondt, W.F.M. (2000). The psychology of underreaction and overreaction in World equity markets. *In* D.B. Keim, & W.T. Ziemba, (eds.). *Security Market Imperfections in World Wide Equity Markets*, (pp.65–89). Cambridge: Cambridge University Press.

Economou, F., Kostakis, A., & Philippas, N. (2011). Cross-country effects in herding behaviour: Evidence from four South European markets. *Journal of International Financial Markets, Institutions and Money*, 21(3), 443–460. doi. 10.1016/j.intfin.2011.01.005

Engle, R.F. (1982). Autoregressive conditional heteroscedasticity with estimates of the variance of United Kingdom inflation. *Econometrica*, 50(4), 987–1007. doi. 10.2307/1912773

Engle, R.F., & Lee, G.G.J. (1999). A long-run and short-run component model of stock return volatility. *In* R.F. Engle, & H. White, (eds.). *Cointegration, Causality and Forecasting – A Festschrift in Honour of Clive W. J. Granger*. Oxford: Oxford University Press.

Engle, R.F., & Patton, A.J. (2001). What good is a volatility model? *Quantitative Finance*, 1(2), 237–245. doi. 10.1016/B978-075066942-9.50004-2

Fakhry, B. (2016). A literature review of the efficient market hypothesis. *Turkish Economic Review*, 3(3), 431–442.

Fakhry, B. (2018). Impact of the crises on the efficiency of the financial market: Evidence from the SDM. Istanbul: KSP Books. [Retrieved from].

Fakhry, B., & Richter, C. (2015). Is the sovereign debt market efficient? Evidence from the US and German sovereign debt markets. *International Economics and Economic Policy*, 12(3), 339–357.

Fakhry, B., & Richter, C. (2016a). Testing the efficiency of the sovereign debt market using an asymmetrical volatility test. *Journal of Management and Training for Industries*, 3(2), 1–15.

Fakhry, B., & Richter, C. (2016b). Testing the efficiency of the GIPS sovereign debt markets using an asymmetrical volatility test. *Journal of Economics and Political Economy*, 3(3), 524–535.

Fakhry, B., Masood, O., & Bellalah, M. (2017). Are the GIPS sovereign debt markets efficient during a crisis? *Journal of Risk*, 19(S1), 27–39.

Fama, E.F. (1965). Random walk in stock market prices. *Financial Analyst Journal*, 21(5), 55–59.

Ferreira, S., & Karali, B. (2015). Do earthquakes shake stock markets? *PLoS ONE*, 10(7), doi. 10.1371/journal.pone.0133319

Gerlach, J.-C., Demos, G., & Sornette, D. (2018). Dissection of Bitcoin's multiscale bubble history from January 2012 to february 2018 [Retrieved from].

Guo, H., & Neely, C.J. (2006). Investigating the intertemporal risk-return relation in international stock markets with the component GARCH model. *Economics Letters*, 99(2), 371–374. doi. 10.1016/j.econlet.2007.09.001

Jiang, Z.-Q., Zhou, W.-X., Sornette, D., Woodard, R., Bastiaensen, K., & Cauwels, P. (2010). Bubble diagnosis and prediction of the 2005–2007 and 2008–2009 Chinese stock market bubbles. *Journal of Economic Behavior and Organization*, 74(3), 149–162. doi. 10.1016/j.jebo.2010.02.007

Lee, H., & Sodoikhuu, K. (2012). Efficiency test in foreign exchange market. *International Journal of Economics and Financial Issues*, 2(2), 216–224.

Lee, W.Y., Jiang, C.X., & Indro, D.C. (2002). Stock market volatility, excess returns and the role of investor sentiment. *Journal of Banking & Finance*, 26(12), 2277–2299. doi. 10.1016/S0378-4266(01)00202-3

Luo, N. (2012). The impact of natural disasters on global stock market: The case of the Japanese 2011 earthquake [Retrieved from].

Maierhofer, S. (2011). 5 Worst disasters –How did the stock market react? [Retrieved from].

Malkiel, B.G. (1962). Expectations, bond prices, and the term structure of interest rates. *The Quarterly Journal of Economics*, 76(2), 197-218. doi. 10.2307/1880816

Malkiel, B.G., & Fama, E.F. (1970). Efficient capital market: A review of theory and empirical work. *The Journal of Finance*, 25(2), 383–417. doi. 10.2307/2325486

Mali, P., & Mukhopadhyay, A. (2014). Multifractal characterization of gold market: A multifractal detrended fluctuation analysis. *Physica A: Statistical Mechanics and its Applications*, 413, 361–372. doi. 10.1016/j.physa.2014.06.076

Masood, O., Aktan, B., Gavurová, B., Fakhry, B., Tvaronavičienė, M., & Martinkutė-Kaulienė, R. (2018). The impact of regime switching behaviour of price volatility on efficiency of the US sovereign debt market. *Economic Research (Ekonomska Istraživanja*), 30(1), 1865–1881. doi. 10.1080/1331677X.2017.1394896

Mele, M. (2015). On the in efficient markets hypothesis: Arbitrage on the forex market. *International Journal of Economics*, 9(2), 111–122. 10.1515/rebs-2017-0050

Narayan, P.K., Narayan, S., & Zheng, X. (2010). Gold and oil markets: Are markets efficient. *Applied Energy*, 87(10), 3299–3303. doi. 10.1016/j.apenergy.2010.03.020

Nofsinger, J.R., & Sias, R.W. (1999). Herding and feedback trading by institutional and individual investors. *Journal of Finance*, 54(6), 2263–2295. doi. 10.1111/0022-1082.00188

Onali, E., & Goddard, J. (2011). Are European equity markets efficient? New evidence from fractal analysis. *International Review of Financial Analysis*, 20(2), 59–67. doi. 10.1016/j.irfa.2011.02.004

Panagiotidis, T. (2010). Market efficiency and the Euro: The case of Athens stock exchange. *Empirica*, 37(3), 237–251. doi. 10.1007/s10663-008-9100-5

Parker, M., & Steenkamp, D. (2012). The economic impact of the canterbury earthquakes. *Reserve Bank of New Zealand Bulletin*, 70(3), 13–25.

Pastor, L., & Stambaugh, R.F. (2012). Are stocks really less volatile in the long run? *The Journal of Finance*, 67(2), 431–478. doi. 10.1111/j.1540-6261.2012.01722.x

Sensoy, A., *and* Tabak, B.M. (2015). Time-varying long term memory in the European Union stock markets. *Physic A*, 436, 147–158. doi. 10.1016/j.physa.2015.05.034

Shiller, R.J. (1979). The volatility of long-term interest rates and expectations models of the term structure. *The Journal of Political Economy*, 87(6), 1190–1219. doi. 10.1086/260832

Shiller, R.J. (1981). The use of volatility measures in assessing market efficiency. *The Journal of Finance*, 36(2), 291–304. doi. 10.2307/2327010

Singh, P., Deepak, C.A., & Kumar, A. (2015). Revisiting weak form efficiency of major equity markets in light of global financial crisis: A panel data approach. *Asia-Pacifc Finance and Accounting Review*, 3(1), 17–44.

Sornette, D., & Cauwels, P. (2015). Financial bubbles: Mechanisms and diagnostic. *Reviews of Behavioral Economics*, 2(3), 279–305. doi. 10.1561/105.00000035

Sosvilla-Rivero, S., & Morales-Zumaquero, A. (2012). Volatility in EMU sovereign bond yields: Permanent and transitory components. *Applied Financial Economics*, 22(17), 1453–1464. doi. 10.1080/09603107.2012.661397

Thaler, R.H. 2015. *Misbehaving: The Making of Behavioural Economics*. Penguin Random House.

Todea, A., & Lazar, D. (2012). Global crisis and relative efficiency: Empirical evidence from Central and Eastern European stock markets. *The Review of Finance and Banking*, 4(1), 45–53.

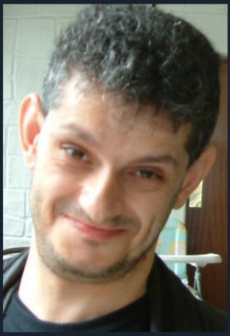
Wang, Y., Wei, Y., & Wu, C. (2011). Analysis of the efficiency and multifractality of gold markets based on multifractal detrended fluctuation analysis. *Physica A: Statistical Mechanics and its Applications*, 390(5), 817–827. doi. 10.1016/j.physa.2010.11.002

Winkler, A. (2014). Rescues violating the German constitution: The federal court decides on a theory of finance. *LSE Financial Markets Group Special Paper Series*, SP No.231.

Zakoian, J.-M. (1994). Threshold heteroskedastic models. *Journal of Economic Dynamics and Control*, 18(5), 931–955. doi. 10.1016/0165-1889(94)90039-6

Zhang, Y., & Wei, Y. (2010). The crude oil market and the gold market: Evidence for cointegration, causality and price discovery. *Resources Policy*, 35(3), 168–177. doi. 10.1016/j.resourpol.2010.05.003

ISBN: 978-605-7736-92-5 (e-Book)
KSP Books 2020



Bachar Fakhry

Christian R. Richter

Professor Bachar Fakhryis currently a non-residential Assistant Professor of Research at the University of Lahore, School of Accountancy & Finance, living in London, UK. His research is in the areas of behavioural finance and econometrics with a special emphasis on the behaviour of European financial markets under uncertainty. He has authored two books and a number of papers on the topic; and co-authored many papers with a number of professors in the field. Additionally, he is an editor at KSP Journal and a referee at a number of other distinguished journals. He has presented his work at a number of academic conferences including many INFER conferences. He received his PhD in Economics from the University of Bedfordshire in 2015, has two master's degrees, one in Distributed Information Systems (1996) the other in Financial Management (2005); both from the University of East London. Previously, he has worked for IBM as a software engineer and Goldman Sachs as a junior economist.

Currently, Richter is Professor of Economics and Head of Dept at the German University in Cairo. In his previous position, Richter was Principal Lecturer in Economics and Management at University of Bedfordshire and University of East London (Economics and Finance). Before that he was a Senior Lecturer in Economics at Kingston University Christian was also a Lecturer in Economics at Loughborough University and Cardiff University. In 2015, Richter won the Ernst Wagemann price for best paper in economics in 2013-2014 in Applied Economics Quarterly. In 2009, Richter won a merit award at Kingston University. Richter has studied economics at the Universities of Mainz, Glasgow and Strathclyde. He received his PhD in economics from University of Strathclyde.Richter is also Honorary Chair of the International Network for Economic Research (INFER) where he is active for many years. Richter has organised several Annual Conferences for INFER (and several workshops), which resulted in several special issues of journals and printed volumes. Richter 's main areas of research are Behavioural Economics and Finance, Convergence of Business Cycles, Eurozone Crisis, Financial Economics, Time Frequency Analysis and Climate Change. Christian won research grants from the Leverhulme Trust as well as from the Austrian Central Bank. Prof. Richter is an editorial board member of International Economics and Economic Policy, International Journal of Public Policy, Romanian Journal of Fiscal Policy and Economic Affairs.

KSP Books

e-ISBN
978-605-7736-92-5
KSP Books 2020