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

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Abstract. 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.
Keywords. Efficient market hypothesis, Volatility tests, Asymmetrical effect, GJR-GARCH, Sovereign debt market, Crises.
JEL. B23, C12, C13, C58, G01, G14, G15, H63.

1. 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.

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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 5and 6 presents the data and empirical results. Finally, section 6 concludes.

2. 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.

3. 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.

4. 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).

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

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

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

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.

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

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:

$$EMHTest = \frac{(\alpha+\beta+\gamma)-1}{standarddevi\ \ ation\ (var\ (x))} \leq Fstatistics \tag{4}$$

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.

5. 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

6. 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.

6.1. 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	0.015970	0.001989	0.005261	0.002262
a	(0.000487)	(0.000257)	(0.000405)	(0.000248)
	0.998053	0.997661	0.991626	1.000558
b	(0.001793)	(0.001765)	(0.001820)	(0.001707)
	0.781356	0.799973	0.819527	0.713470
u	(0.012194)	(0.011800)	(0.013501)	(0.013905)
Variance Equation	1.49E-05	4.49E-06	1.49E-05	4.19E-06
ω	(2.94E-06)	(9.00E-07)	(2.50E-06)	(1.08E-06)
α	1.56118	1.844676	1.51262	2.257028
	(0.245778)	(0.335691)	(0.275942)	(0.462730)
β	0.089461	0.061464	0.075603	0.098107
	(0.026248)	(0.023683)	(0.023654)	(0.027931)
γ	-0.044722	-0.113284	-0.209147	-0.177109
	(0.368074)	(0.430284)	(0.331943)	(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 Stat	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
Standard Deviation	0.189977	0.116066	0.157186	0.141228
EMH Test				
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.

6.2. 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.

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.

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

	Greek	Italian	Portuguese	Spanish
Mean Equation				
a	0.034489 (0.100328)	0.002517 (4.29E-05)	0.005097 (0.000137)	0.003162 (8.54E-05)
b	0.982734 (0.004985)	0.969560 (0.001634)	0.984177 (0.000865)	0.999832 (0.001766)
u	1.138810 (0.038076)	0.829390 (0.012387)	0.745970 (0.012060)	0.836750 (0.012703)
Variance Equation				
ω	0.697604 (0.104858)	1.46E-07 (3.20E-08)	4.42E-07 (2.02E-07)	5.17E-07 (1.55E-07)
α	0.711551 (0.179001)	2.093871 (0.318346)	2.195565 (0.236310)	2.775620 (0.592585)
β	-0.00614 (0.000157)	0.055148 (0.026693)	0.267627 (0.014937)	0.094363 (0.024345)
γ	-0.02664 (0.256421)	-0.50411 (0.423612)	-0.95724 (0.285304)	-1.00184 (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 Stat	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
Standard Deviation	11.48550	0.064861	1.517370	0.190863
EMH Test				
EMH Test Statistics	-0.02797	9.942986	0.333442	4.548493
Efficiency	Accept	Reject	Accept	Reject

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).

7. 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.

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