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5 April 2017

Online at <https://mpra.ub.uni-muenchen.de/78595/>

MPRA Paper No. 78595, posted 19 Apr 2017 11:29 UTC

# **Dependence of Stock Markets with Gold and Bonds under Bullish and Bearish Market States**

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## **Abstract**

This paper examines the dependence of gold and benchmark bonds with ten stock markets including five larger developed markets (e.g. USA, UK, Japan, Canada and Germany) and five Eurozone peripheral GIPSI countries (Greece, Ireland, Portuguese, Spain and Ireland) stock markets. We use a novel quantile-on-quantile (QQ) approach to construct the dependence estimates of the quantiles of gold and bond with the quantiles of stock markets. The QQ approach, recently developed by Sim and Zhou (2015), captures the dependence between the entire distributions of financial assets and uncovers some nuance features of the relationship. The empirical findings primarily show that gold is strong hedge and diversifier for the stock portfolio except when both the markets are under stress. Further, the flight to safety phenomenon is short-lived because national benchmark bonds exhibit a positive dependence with their respective countries stock indices at various quantiles. Unlike the existing literature, the QQ approach suggest that bonds act as safe havens for the stock portfolio but gold does not. Our findings also suggest that dependence between stock-gold and stock-bond pairs is not uniform and this relationship is market state (e.g. bearish, mild bearish, optimistic or bullish) and country specific.

**Keywords:** Stock, Gold, Quantile-on-Quantile, Diversification

## 1. Introduction

The global events that have shaken the world economy are now more insistent and frequent in large developed and emerging economies worldwide. The synchronization of economic sectors and sustainable international financial integration are considered as the essentials for the market turbulences (Rejeb and Arfaoui, 2016). The nature of dependence across various assets returns is of immense importance for portfolio allocation, policy formulation and for asset pricing. The investors are now paying close attention to interdependence between assets, especially between stock markets returns and alternative assets to gain risk-return trade off from international diversification (Bekaert et al. 2014) as the misappropriation can affects the portfolio return during market turmoil. Therefore, dependence between assets is important to determine how strongly the assets are interlinked and can influence each other. These consequences are important for risk management (Mensah and Alagidede, 2017), and given to diversification principles, investing in low correlated assets may reduce the probability of losses on investment.

Modeling the dependence structure between financial assets is of immense importance to construct an optimal portfolio, and it is appropriate to choose assets whose values rise and fall independently (Sim, 2016). However, to determine correlations structure the naïve techniques are often uninformative about the actual interdependence between assets. For instance, to determine the negative return of an asset's (10<sup>th</sup> percentile) usually followed by the negative returns of the other asset's (10<sup>th</sup> percentile) cannot be addressed while looking at sample correlation coefficient as produced from the naïve techniques (Reboredo and Ugolini, 2016; Shahzad et al., 2016; Sim and Zhou, 2015). To depict either the negative (lower quantile) returns tend to occur together, hence, it would be worthwhile to examine the dependence between assets quantiles, but application of these models is scarce. The QQ approach allows us to examine the dependence

structure between the entire distributions of the markets and hence some reliable conclusions on the hedge, diversification and safe haven properties of gold and bond can be drawn.

The findings suggest that gold has negative dependence with major developed and GIPSI stock markets across majority of quantiles especially those associated with normal and bullish market states. The low or negative dependence between gold and stock portfolios highlight the hedge and safe haven properties of the gold; however, these properties are subject to the state of a particular stock and gold market. On other hand, when both stock and gold markets are pessimistic i.e. undergoing stress periods, gold shows positive dependence with stock markets and hence both markets may co-crash together. This finding is worth noting and requires caution as the investors may suffer losses in a effort to search the safe havens for their stock investment. This finding, in line with Bekiros et al. (2017), indicate that increased financialization of the commodity markets has resulted in accessibility for gold trading and eventually a closer tie between stock and gold markets. For the Eurozone stock markets, i.e. GIPSI countries, the hedging ability of gold is also weak only in the extreme bearish market conditions, but at intermediate to upper quantiles gold served its traditional role as diversifier assets. A similar heterogeneity, at various quantiles, of dependence between benchmark bonds and respective stock indices is noted. We infer that under-estimating the hedging and diversification potential of bonds could lead to lower diversification benefits as bonds have negative dependence with respective stock portfolios especially when both the markets are under stress. Finally, the sizeable variations, across different quantiles presenting unique market conditions, of the dependence structure between investable assets require investors' attention while making portfolio and risk management decisions.

Overall, the dependence between stock-gold and stock-bond is not uniform, but this relationship is market (e.g. bearish, mild bearish, optimistic or bullish) and country specific. The flight to safety phenomenon is short-lived and is in line with the conventional wisdom that common macroeconomic conditions, such as the expected inflation or economic prospects, drive the investable assets universe.

The rest of the paper is set out as follows. Section 2 provides the review of related literature and section 3 presents the methodology employed to determine the Quantile dependence between financial assets. Section 4 provides an overview of dataset and presents preliminary analysis, while the Section 5 describes the key findings of dependence structure using QQ approach. Finally, Section 6 offers some concluding remarks and practical implications.

## **2. Related Literature**

Interdependence between any two markets is evident when there is a high degree of co-movement during periods of stability and after a shock to one market. This continued high level of market correlation suggests strong linkages between the two economies that exist in all states of the world. The interdependence between financial markets amplifies the volatility spillovers from one market to other through a mechanism of contagion and makes them more sensitive to external common shocks (Rejeb, 2013; Bekiros, 2014; Gilenko and Fedorova, 2014). Hence, it is believed that the rigorous study on financial assets interdependencies in terms of quantiles would be useful for portfolio manager, financial analysts and for government policy regulators. Investors and financial analysts often emphasized that gold acts as an alternative investment asset to counter market risk in times of market stress, and not surprisingly, the hedge and safe haven potentials of gold have been extensively analyzed in market jitters (Baur and Lucey 2010, Baur

and McDermott 2010, Hood and Malik 2013), it is believed that adding gold to a stock portfolio reduces the risk of portfolio without losing the desire average returns (Ciner et al. 2013, Mensi et al. 2015, Bredin et al. 2015, Adam et al. 2015). On other hand, beauty of gold is to love the bad news, and in response to adverse stock market movement its rising prices compensate the portfolio losses (Arouri et al. 2015, Beckmann et al. 2015, Śmiech and Papież 2016, Chkili 2016, Basher and Sadorsky 2016, Raza et al. 2016). Also, compensate investors for many deterioration in purchasing power due to inflation or currency depreciation (Wang and Lee 2016, Aye et al. 2016, Iqbal et al. 2016).

Similarly, the correlation between stock and bonds returns decrease during stock market declines, (Guidolin and Timmermann, 2005) and also a massive capital flow has been witnessed to both stock and bond market, especially when stock market is flooded with liquidity. This moves the bond and stock prices in opposite direction, which encourages the investors to shifts their investment from risky assets e.g. stocks to safe haven assets like bonds (Baele et al. 2013, Pieterse-Bloem et al. 2016), referred as “flight-to-safety”, phenomenon. Hence, it turned the stock-bond return relation to negative and entices investors to revise their asset allocation according to the current market situations (Zheng et al. 2016). Generally, it is a good practice to invest in low correlated assets, but this seemingly complicated because dependence between many assets is contingent to their price movements. As earlier documented that the standard measures of correlation betray the actual dependence exists between assets (e.g. Erb et al. 1994, Longin and Solnik 1995, Ang and Chen 2002, Sim and Zhou 2015). Previous studies employed the techniques such as regime-switching to model jumps in correlations of assets returns and applied extreme value theory (EVT) to mode the tail dependence which usually imitates the extreme events (See e.g., Ang and Bekaert (2002), Ang and Chen (2002), Bejaoui and

Karaa(2016), Guidolin and Timmermann (2005), Herffernan and Tawn 2004, Poon et al., (2004), among others). Mensi et al. (2014) applied quantile regression to examine the interdependence between global economic factors and returns of the BRICS stock markets, and depicted that the dependence structure is asymmetric and contingent to global financial crisis. Similarly, Zhu et al. (2015) also found significant asymmetric dependence between chines stock returns and global stock markets. Lee and Yang (2014) determine the interdependence between financial markets while using Granger causality in quantiles and found significant improvement in causal relation as compared to the relation determined through standard quantile regression approach. Nath and Brooks (2015) measure the dependence between idiosyncratic risk and stock return while using GARCH and quantile regression approaches and found that the idiosyncratic risk–return puzzle is a model specification problem. However, White et al. (2015) estimate a multi-quantile model to analyze the risk spillovers between stock market and financial institutions; they argued that their methodology can prove a valuable addition to the traditional toolkit of quantile regression. More recently, Mensi et al. (2016) examined the tail dependence between GCC stock markets return and global macroeconomic variables while using wavelet based quantile, and found strong asymmetric dependence at middle quantile.

In conclusion, these techniques consider changes in correlations as discrete events. Therefore, are not appropriate to model the dependence between financial assets when markets are, said to be bullish or bearish. More specifically, the market situation, e.g. “mild” is somewhat difficult to conceptualize with these naïve techniques. From this perspective, the Quantile-on-Quantile approach is more suited to be used, because the assets returns are plausible indicator of how well they are performing in specific quantiles. To the best of our knowledge, this study is the first which model the risk contagion and dependence between stocks returns of ten countries, their

respective government bonds and gold returns through Quantile on Quantile approach. The linkages between these financial assets can be contingent to different global shocks (e.g. if the data period is marked by the global financial crisis). Therefore, the Quantile on Quantile approach is able to detect such asymmetries and thus, provide better information about the pertaining correlation in various market conditions.

### **3. Methodology: Quantile-on-quantile approach**

This section briefly describes the key features of the QQ approach (Sim and Zhou 2015) and the model specification used in this study to examine the relationship stock-gold and stock-bond.

The QQ method can be seen as a generalization of the standard quantile regression approach which enables one to examine how the quantiles of a variable affect the conditional quantiles of another variable. The QQ approach is based on the combination of quantile regression and nonparametric estimation. First, conventional quantile regression is utilized to estimate the effect of an explanatory variable on the different quantiles of the dependent variable. The quantile regression methodology developed by Koenker and Bassett (1978) can be regarded as an extension of the classical linear regression model. Thus, allowing a more comprehensive characterization of the linkage between variables by examining the tails of distribution of dependent variable. Second, local linear regression is employed to estimate the local effect of a specific quantile of the explanatory variable on dependent variable. The local linear regression introduced by Stone (1977) and Cleveland (1979) avoids the so-called “curse of dimensionality” problem associated with purely nonparametric models. Therefore, by combining these two approaches it is possible to model the relationship between quantiles of explanatory variable and



quantiles of dependent variable, providing a greater amount of information than alternative estimation techniques such as OLS or standard quantile regression.

In the framework of the present study, the QQ approach proposed to investigate the dependence between stock and hedge instruments (i.e., gold or bond), through following nonparametric quantile regression model:

$$SP_t = \beta^\theta(HI_t) + u_t^\theta \quad (1)$$

Where  $SP_t$  represents the stock returns of a given country in period  $t$ , and  $HI_t$  denotes the hedge instruments in that country in period  $t$ ,  $\theta$  is the  $\theta$ th quantile of conditional distribution of stock return and  $u_t^\theta$  is a quantile error term whose conditional  $\theta$ th quantile is equal to zero. The  $\beta^\theta(\cdot)$  is an unknown function since we have no prior information on how financial assets are linked.

This quantile regression model measures the impact hedge instrument ( $HI$ ) on the distribution of the stock returns of a country whilst allowing the effect of hedge instrument ( $HI$ ) to vary across different quantiles of stock returns. The main advantage of this specification is its flexibility as no hypothesis is made about the functional form of the relationship between financial assets such stock-gold and stock-bond. However, a shortcoming of the quantile regression approach is its ability to capture dependence in its entirety. In this regard, the quantile regression model does not take into account the possibility that the nature of gold and bond market shocks may also influence the way in which hedge instruments and stock returns are related. For instance, the effect of large positive hedge instrument market shocks can be different from the effect of small positive shocks.

Then, in order to analyze the relationship between the  $\theta$ th quantile of real stock and the  $\tau$ th quantile of  $HI$ , denoted by  $HI^\tau$ . Eq. (1) is examined in the neighborhood of  $HI^\tau$  using local linear

regression. As  $\beta^\theta(\cdot)$  is unknown, this function can be approximated through a first order Taylor expansion around a quantile  $HI^\tau$  such that:

$$\beta^\theta(HI_t) \approx \beta^\theta(HI^\tau) + \beta^{\theta'}(HI^\tau)(HI_t - HI^\tau) \quad (2)$$

Where  $\beta^{\theta'}$  is the partial derivative of  $\beta^\theta(HI_t)$ , with respect to  $HI$ , also called marginal effect or response and is similar in interpretation to the coefficient (slope) in a linear regression model.

A prominent feature of Eq. (3, g) is that the parameters  $\beta^\theta(HI^\tau)$  and  $\beta^{\theta'}(HI^\tau)$ , are doubly indexed in  $\theta$  and  $\tau$ . Given that  $\beta^\theta(HI^\tau)$ , and  $\beta^{\theta'}(HI^\tau)$ , are functions of  $\theta$  and  $HI^\tau$  are a function of  $\tau$ , it is obvious that  $\beta^\theta(HI^\tau)$  and  $\beta^{\theta'}(HI^\tau)$  are both functions of  $\theta$  and  $\tau$ . In addition,  $\beta^\theta(HI^\tau)$  and  $\beta^{\theta'}(HI^\tau)$  can be renamed as  $\beta_0(\theta, \tau)$  and  $\beta_1(\theta, \tau)$ , respectively. Accordingly, Eq. (3) can be rewritten as:

$$\beta^\theta(HI_t) \approx \beta_0(\theta, \tau) + \beta_1(\theta, \tau)(HI_t - HI^\tau) \quad (3)$$

By substituting Eq. (3) from Eq. (1), the following equation is obtained:

$$SP_t = \underbrace{\beta_0(\theta, \tau) + \beta_1(\theta, \tau)(HI_t - HI^\tau)}_{(*)} + u_t^\theta \quad (4)$$

As can be seen, the part (\*) of Eq. (4) is the  $\theta$ th conditional quantile of stock return. However, unlike the standard conditional quantile function, this expression reflects the relationship between the  $\theta$ th quantile of the stock and the  $\tau$ th quantile of the hedge instrument, since the parameters  $\beta_0$  and  $\beta_1$  are doubly indexed in  $\theta$  and  $\tau$ . These parameters may vary across different  $\theta$ th quantiles. Moreover, at no time a linear relationship is assumed between the quantiles of the variables under study. Therefore, Eq. (4) estimates the overall dependence structure between stock and hedge instruments through the dependence between their respective distributions.

To estimate Eq. (4), it is necessary to replace  $HI_t$  and  $HI^\tau$  by its empirical counterparts  $\widehat{HI}_t$  and  $\widehat{HI}^\tau$ , respectively. The local linear regression estimates of the parameters  $b_0$  and  $b_1$ , which are the estimates of  $\beta_0$  and  $\beta_1$ , are obtained by solving the following minimization problem:

$$\min_{b_0, b_1} \sum_{i=1}^n \rho_\theta [SP_t - b_0 - b_1(\widehat{HI}_t - \widehat{HI}^\tau)] K\left(\frac{F_n(\widehat{HI}_t) - \tau}{h}\right) \quad (5)$$

Where  $\rho_\theta(u)$  is the quantile loss function, defined as  $\rho_\theta(u) = u(\theta - I(u < 0))$  being  $I$  the usual indicator function. The  $K(\cdot)$  denotes the kernel function and  $h$  is the bandwidth parameter of the kernel.

The Gaussian kernel, which is one of the most popular kernel functions in economic and financial applications because of its computational simplicity and efficiency, is used in this study to weight the observations in the neighborhood of  $HI^\tau$ . The Gaussian kernel is symmetric around zero and assigns low weights to observations further away. Specifically, in our analysis these weights are inversely related to the distance between the empirical distribution function of  $\widehat{HI}_t$ , denoted by  $F_n(\widehat{HI}_t) = \frac{1}{n} \sum_{k=1}^n I(\widehat{HI}_k < \widehat{HI}_t)$ , and the value of the distribution function that corresponds with the quantile  $HI^\tau$ , denoted by  $\tau$ .

The choice of the bandwidth is important when using nonparametric estimation techniques. The bandwidth determines the size of the neighborhood around the target point and, therefore, it controls the smoothness of the resulting estimate. The larger the bandwidth, the bigger the potential for bias in estimates, while a smaller bandwidth can lead to estimates with higher

variance. Thus, a bandwidth that strikes a balance between bias and variance must be chosen. Following Sim and Zhou (2015), a bandwidth parameter  $h = 0.05$  is employed in this study.<sup>1</sup>

## **4. Data and Preliminary Analysis**

### *4.1. Data Overview*

The dataset consists of monthly returns of ten stock markets including USA, UK, Japan, Canada and Germany which represents the major developed markets in the world, and five Eurozone countries (GIPSI) stock markets which were considered weaker economically in recent European debt crisis. The GIPSI is an acronym used to refer; Greece, Ireland, Portugal, Spain and Italy. The motivation to examine the GIPSI countries stock market stems from the impact of recent sovereign debt crisis that unfolds at the end of 2009. These Eurozone peripheral countries stock markets were severely impacted by the European sovereign debt crisis (Avdoulas et al., 2016). Increase in sovereign credit risk may trigger doubts on the governments' ability to offer a credible guarantee to financial institutions in case of distress. These peripheral Eurozone countries (Greece, Ireland, Portugal, Spain and Italy) were unable to refinance their government debt and failed to bail out their financial institutions without the support of third party i.e., European Central Bank (Fadejeva et al., 2017). These effects have contributed to severe decline in the real activity in Eurozone during stressed period (Chudik and Fratzscher, 2011). This stylized fact might be owed that these GIPSI countries are still and were at the center of European debt crisis. Thus, it is more useful to analyze the quantile dependence between financial assets such as stock-gold and stock-bond, which includes the stock markets showing different trends e.g. extreme bearish, mild bearish, optimistic and bullish. The study chooses the sample from the

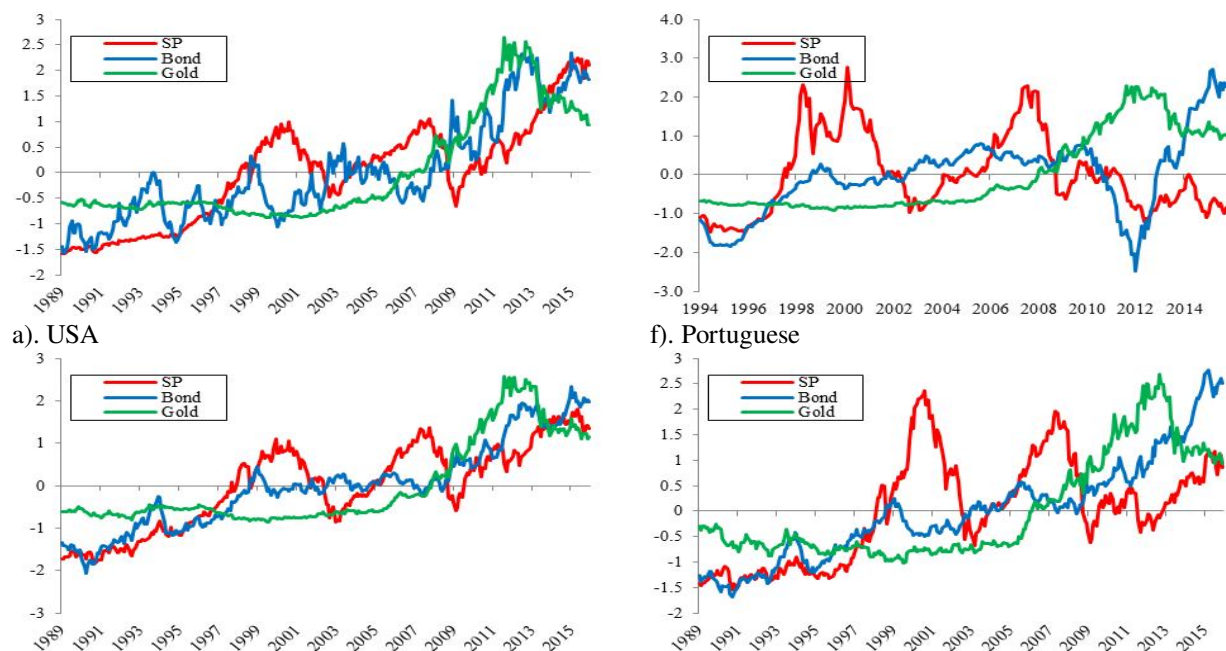
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<sup>1</sup>A number of alternative values of the bandwidth have been also considered and the results of the estimation remain qualitatively the same.

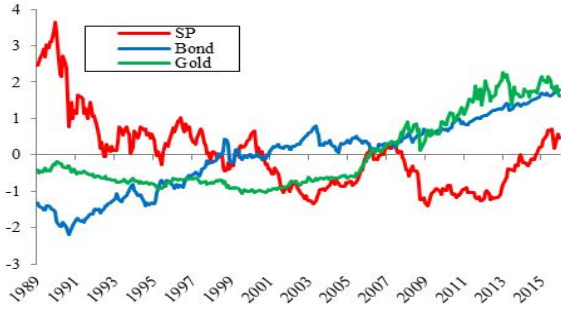
date where the data on all three variables is available. For, instance, data period is starting from January 1989 in case of Canada, Ireland, Germany, Japan, UK and USA, Spain from January 1991, Portuguese from January 1994 and for Italy and Greece it is started from April 1998. However, the ending period of all the data is same i.e., December 2015. Moreover, we have utilized the 10 years benchmark bond price index for each country as proxy for the bond markets, and monthly gold prices (US dollar troy/ounce) for gold market. All the data is denominated in local currencies, where data on stock and benchmark bond price indices is obtained from DataStream and gold prices are sourced from World Gold council.

Figure 1 illustrates the trajectory of the monthly returns over the sample period. Figure 1 displays a spectacular rise in the gold returns in 2007 as compared to stock and benchmark bonds returns, while it shows a significant decline for most of the period dating back to global financial crisis that is market as the pre-crisis period. The continuously compounded monthly returns are computed by taking the difference in the logarithm of two consecutive prices.

**Figure 1:** Time trend of markets – standardized prices



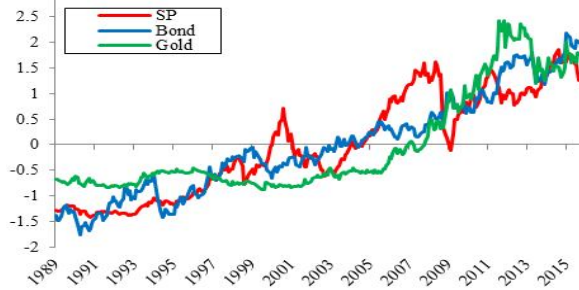
b). UK



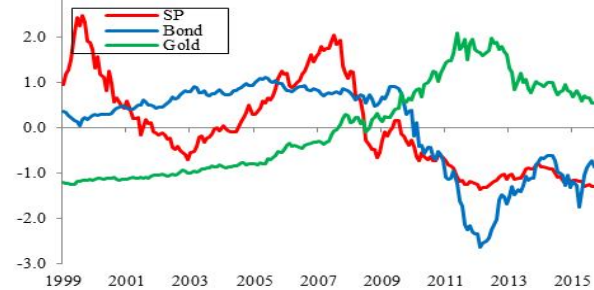
g). Ireland



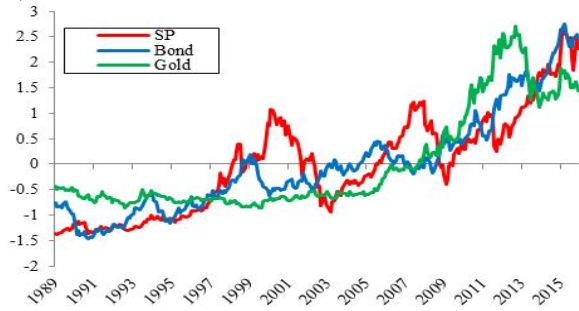
c). Japan



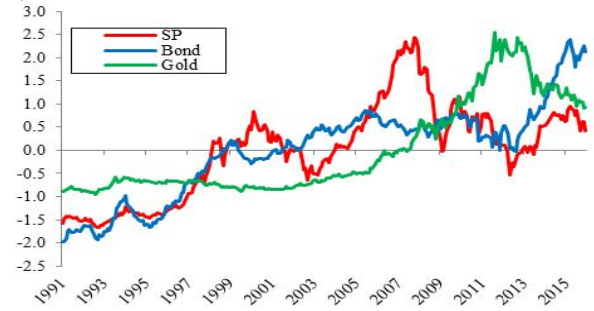
h). Italy



d). Canada



i). Greece



e). Germany

j). Spain

#### 4.2. Descriptive Statistics

The descriptive statistics reported in Table 1 show that the average monthly returns on all stock indices (Panel A) under consideration are positive and close to each other, except Japan, Italy and Greece where these are negative. However, monthly returns on benchmark bonds (Panel B), are lower than the returns on stock indices. Particularly, the benchmark bonds of Spain and Portuguese exhibited high returns (i.e., 0.0037 and 0.0025), respectively in our sample period. Moreover, in comparison to benchmark bonds returns, gold (Panel C) have higher returns which are highest in case of Greece and Japan (i.e. 0.0077 and 0.0057), respectively. The standard

deviation is the lowest for the benchmark bond indices and the highest for stock indices in each country. The standard deviation of gold is slightly higher than benchmark bonds, but lower than stock indices. Stock and benchmark bond indices exhibited negatively skewed return distributions, except the benchmark bonds of Portuguese and Spain which shows positively skewed distributions. In addition to, the gold returns in USA along with GIPSI countries exerted negatively skewed distributions.

**Table 1:** Descriptive statistics of monthly returns

	Mean	Minimum	Maximum	Std. Dev.	Skewness	Kurtosis	J-B Stats
<b>Panel A: Stock market returns</b>							
USA	0.0060	-0.1856	0.1058	0.0421	-0.7626	4.6778	69.18***
UK	0.0037	-0.1441	0.1042	0.0413	-0.6076	3.7297	27.04***
Japan	-0.0012	-0.1831	0.1909	0.0637	-0.2345	3.7432	6.9184**
Canada	0.0040	-0.2258	0.1119	0.0418	-1.1559	7.0703	294.8***
Germany	0.0065	-0.2933	0.1937	0.0622	-0.8996	5.6220	136.1***
Portuguese	0.0004	0.1719	-0.2335	0.0592	-0.4397	4.3450	28.29***
Ireland	0.0032	-0.1923	0.1259	0.0547	-0.5087	3.3492	15.57***
Italy	-0.0016	-0.2722	0.1829	0.0625	-0.5019	4.0470	28.31***
Greece	-0.0091	0.1985	-0.3267	0.0903	-0.5239	3.7458	13.78***
Spain	0.0048	0.1519	-0.2151	0.0581	-0.4042	3.8187	16.49***
<b>Panel B: Bond index returns</b>							
USA	0.0012	-0.0772	0.0916	0.0208	-0.0031	4.2996	22.73***
UK	0.0018	-0.0579	0.0600	0.0194	-0.0600	3.3769	2.1053
Japan	0.0021	-0.0758	0.0778	0.0197	-0.0593	5.7714	68.92***
Canada	0.0020	-0.0725	0.0527	0.0185	-0.1135	3.6731	6.7914**
Germany	0.0016	-0.0637	0.0517	0.0159	-0.2471	3.5446	7.2784**
Portuguese	0.0025	0.1856	-0.1680	0.0337	0.2190	10.351	594.2***
Ireland	0.0022	-0.0478	0.0530	0.0171	-0.1141	2.9377	0.7527
Italy	0.0016	-0.0693	0.0519	0.0142	-0.4234	6.5179	176.2***
Greece	-0.0023	0.3567	-0.5606	0.0861	-1.5059	15.3192	1340.2***
Spain	0.0037	0.0904	-0.1015	0.0229	0.0960	5.5174	79.41***
<b>Panel C: Gold returns</b>							
USA	0.0031	-0.1910	0.1600	0.0451	-0.1112	4.5267	32.03***
UK	0.0036	-0.1573	0.1601	0.0474	0.0811	3.6120	5.3953*
Japan	0.0057	-0.1599	0.1518	0.0482	0.1002	3.6698	4.3788**
Canada	0.0036	-0.1364	0.1446	0.0430	0.2108	3.9328	14.10***
Germany	0.0029	-0.1594	0.1517	0.0468	0.0314	3.6404	5.5732*
Portuguese	0.0043	0.1601	-0.1573	0.0465	-0.0964	3.8927	9.1408**
Ireland	0.0016	-0.1710	0.1503	0.0462	-0.0166	4.0666	15.32***
Italy	0.0028	-0.2674	0.1306	0.0486	-0.8239	6.2700	180.4***
Greece	0.0077	0.1604	-0.1545	0.0496	-0.1484	3.8240	6.3915**
Spain	0.0050	0.1524	-0.1545	0.0474	-0.0218	3.8277	8.5596**

**Note:** \*\*\*, \*\* and \* indicate significance at 1%, 5% and 10% level, respectively

Further, the kurtosis and Jarque-Bera test statistics show that the return series are not normally distributed in each case. The null hypothesis of normality is rejected at 1% level of significance.

## 5. Empirical Findings

### 5.1. Estimates of the QQ approach

The quantile dependence between stock-gold is presented in this section. Figure-2 (a-j) displays the estimate of the slope coefficient  $\hat{\beta}_{(\theta,\tau)}$  that captures the dependence between the  $\tau$ th quantile of gold and the  $\theta$ th quantile of stock returns for the ten countries under consideration. The QQ estimates of the slope coefficient,  $\hat{\beta}_{(\theta,\tau)}$  are displayed at the z-axis against the quantiles of stock and gold returns on x and y axis, respectively. The QQ approach allows us to examine the dependence structure between the entire distributions of the markets and hence some reliable conclusions on the hedge, diversification and safe haven properties of gold and bond can be drawn. In line with the proposition of Baur and Lucey (2010), we hypothesize that gold/bond is a hedge when it has zero and/or negatively correlation with the stocks portfolio, a diversifier when it has a positive but less than perfect correlation with the stocks portfolio, and finally gold is a safe haven when gold exhibit hedging properties for the stocks portfolio during the crises/extreme market situations (for the lower quantiles). The results for developed and GIPSI stock markets are shown in Panel A and B, respectively. Examining the results by country, a pronounced negative relationship can be seen for the clear majority of the selected countries. For instance, the strong negative dependence is evident for all quantiles of U.S stock and gold returns, except during the extreme bearish states in both stock and gold markets (i.e. < 0.2 quantiles). The higher dependence during the bearish states implies that the hedging ability of the gold is short-lived and may not be present during extreme bearish market conditions. The



dependence between gold and stock returns is quite weak in case of UK and Japan. More specifically, the stock-gold dependence has extremely low i.e. close to zero values at most of the quantiles. This indicates that gold can serve as a hedge and diversifier for UK and Japan stock markets during mild bearish and bullish market conditions. We infer that investors can diversify their stock portfolios by investing in a relatively safe asset i.e., gold only during the stable market conditions in both markets. Generally, when the stock prices decrease, the gold prices increase (see Figure-1). This is in line with the reported literature (e.g. Baur and McDermott 2010, Ciner et al. 2013, Mensi et al. 2015, Bredin et al. 2015, Beckmann et al. 2015, Śmiech and Papież 2016, Raza et al. 2016). However, the main exceptions are the extreme bearish conditions in both stock and gold markets i.e. the lowest quantiles of stock (less 0.2) with that of lower and middle quantiles of gold (i.e. 0.2-0.4). The relatively higher dependence in extreme lower quantiles imply that extreme declines in USA, UK and Japanese stock markets contribute to the aggravation of the gold returns as well.

Notably, gold exhibits relatively strong dependence with Canadian stock market in the area that combines the lower quantiles of stock (i.e.  $< 0.2$ ) with the intermediate to upper quantiles of gold (0.6-0.9). This implies that extreme negative shocks (extreme bearish trends) in Canadian stock market are also coupled with bad performance in the gold market. Primarily in times of mild bearish trend, gold exerts positive dependence with stock market. This positive dependence takes place in the vicinity of  $\theta = 0.2 - 0.4$  and  $\tau = 0.6$ , shows that during the times of mild bearish equity trends, gold fails to generate such positive returns. However, when stock market is in normal time (neither bearish nor bullish), for example at its median quantile i.e.  $0.4 - 0.6$ , gold returns are weakly related with the stock returns as  $\hat{\beta}_{(\theta, \tau)} = 0$ , implying that there is apparently no significant relationship between stock and gold quantiles. However, during bullish market trends

that is shown by the upper quantile ( $\theta \geq 0.8$ ), stock and gold markets are positively associated with each other. The connection between gold and stock markets of Germany is also predominantly positive during extreme bearish conditions. In this case, the strongest positive relation is manifested in the area that combines the lowest quantile of stock (i.e.  $< 0.2$ ) with lower (0.2-0.4) and upper (i.e.  $\geq 0.8$ ) quantiles of gold.

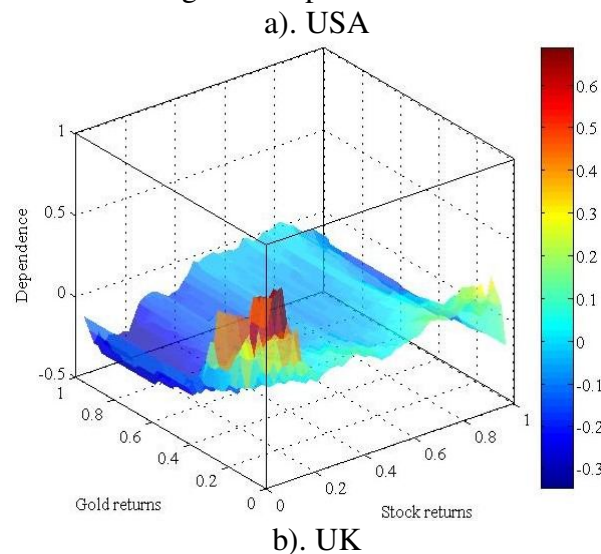
These findings suggest that gold provides hedging and diversification benefits to the major stock markets of the investment universe (e.g. USA, UK, Japan, Canada and Germany) during mild bearish, optimistic and bullish situations. A possible explanation for this phenomenon is that they are also known as the world major gold consumer countries and investment in gold has been motivated by the fears of inflation and political instability. The quantile dependence between gold and stock returns across different countries show a positive dependence during the extreme bearish market states. This finding indicates that gold may not act as a safe haven for the stock markets especially when both the markets are under stress and that the shocks in stock markets are quickly transmitted to the gold market.

The evidence of differential impact of gold on stock returns across different quantiles indicates that: (a) in the bearish stock market states when stock return shows decreasing pattern gold prices shows increasing trends. The gold is generally hedge against uncertainties and loves the bad news, as the so-called flight to quality phenomenon, and provides diversification benefits to the investors and hedge against inflation and other uncertainties (b) when both stock and gold markets are bearish, gold exhibits a positive dependence with stock markets return. However, among other commodities and precious metals, gold is quite unique and is virtually considered as a distinct asset class (Batten et al. 2014), and its usefulness as a financial asset is far greater when compared with its traditional use in jewelries and ornaments (Batten et al. 2010).

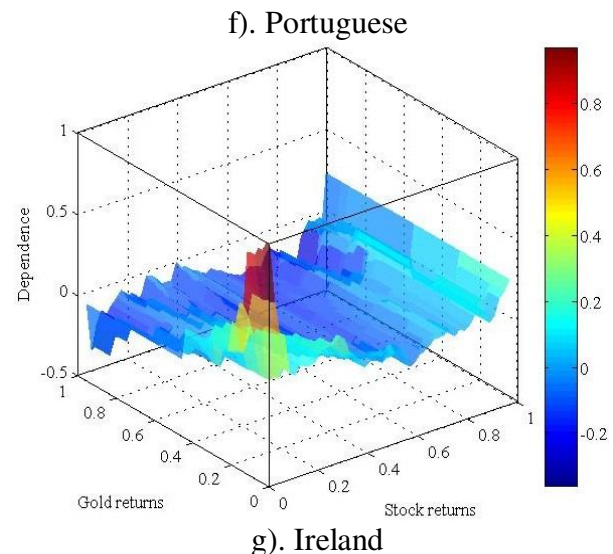
On the other hand, GIPSI (Greece, Ireland, Portuguese, Spain and Italy) stock markets share some commonalities regarding the quantile dependence between stock and gold. In these countries stock-gold dependence is negative for majority of quantiles, for example, in optimistic (0.4-0.6) and bullish ( $\geq 0.8$ ) quantiles. However, the intensity of the negative dependence is not high in case of Italy and Greece, which suggest that gold is not a perfect hedge in these markets. In general, the most heightened positive connections are witnessed in the areas combining the lowest quantiles of GIPSI stock portfolios (i.e. less 0.2) with the lowest quantiles of the gold. We infer that the significant drop in the stock market appear to have led to further deterioration in the gold market. Our findings suggest that relationship between stock and gold significantly depends on the bearish and/or bullish states in both gold and stock markets. Therefore, hedging ability of gold does not only depend on the market states in stock universe rather it also depends on the prevailing sentiments in the gold markets.

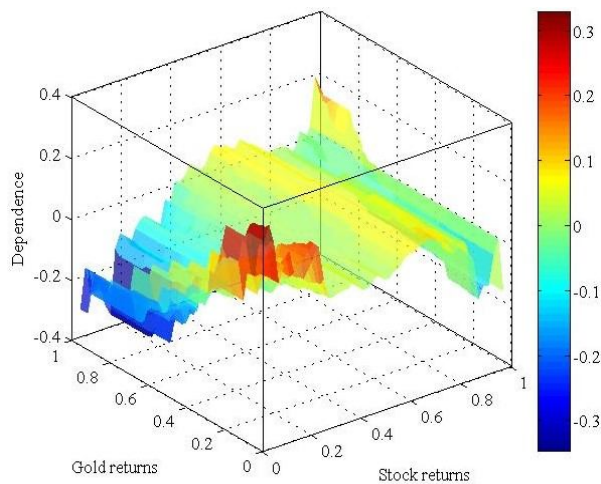
**Figure 2:** QQ estimates of the slope coefficient,  $\hat{\beta}_{(\theta,\tau)}$  : Stock returns (right) – Gold Returns (left)

**Panel A:** Large developed markets

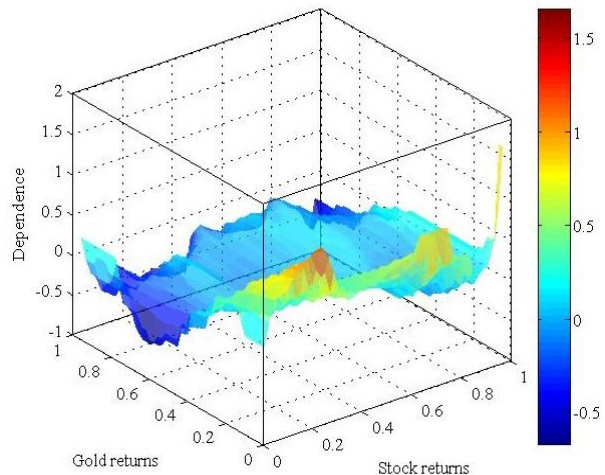


**Panel B:** GIPSI markets

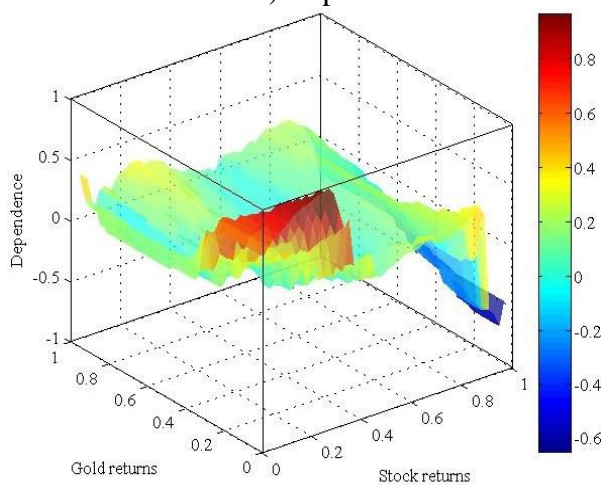




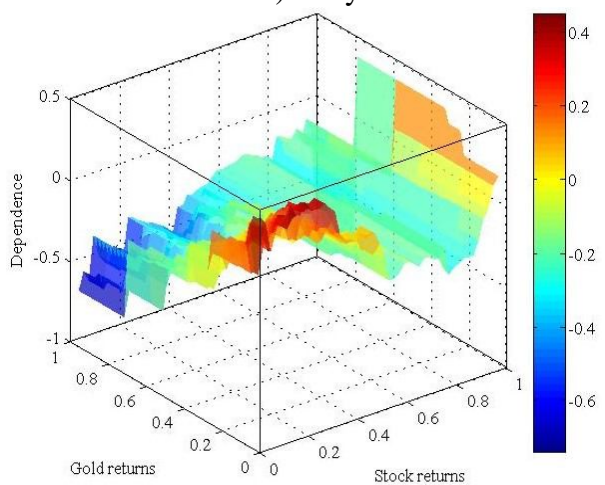
c). Japan



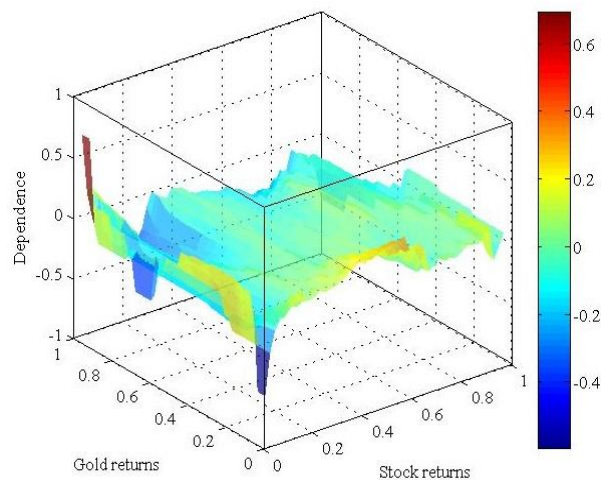
h). Italy



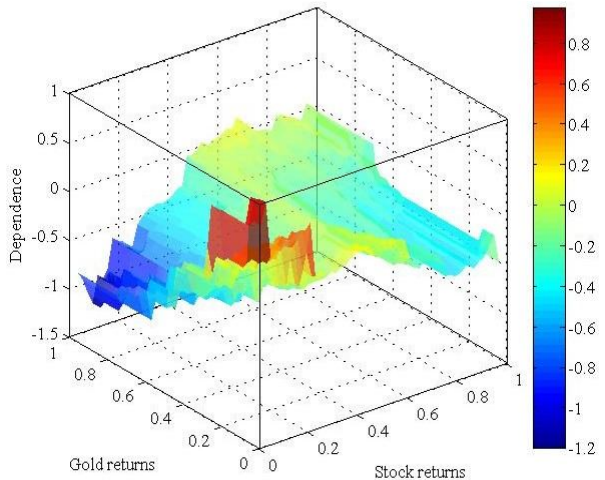
d). Canada



i). Greece



e). Germany



j). Spain

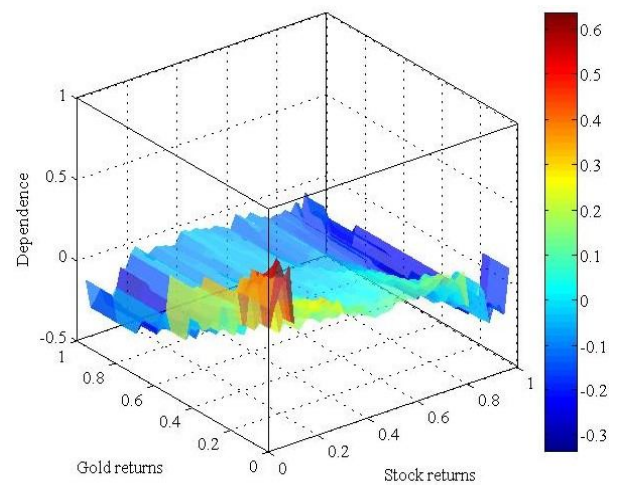
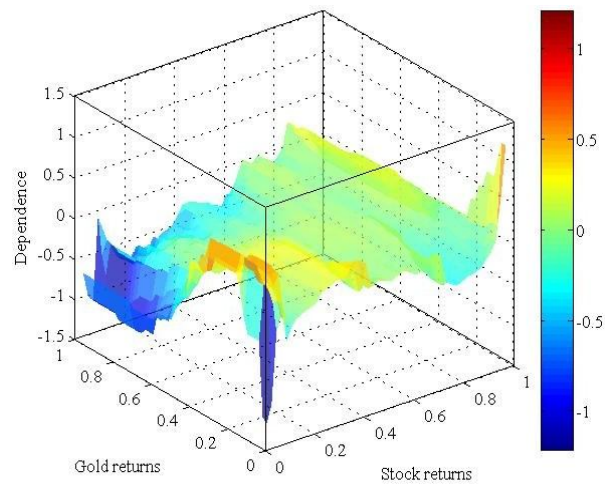


Figure 3 (a-j) reveals the quantile dependence between stock and respective bond indices, where the estimated slope coefficient  $\hat{\beta}_{(\theta,\tau)}$  shows the effect of the  $\tau$ th quantile of benchmark bond index on the  $\theta$ th quantile of stock returns of the respective country. Similar to stock-gold relation, we divide the quantiles according to market condition like lowest quantile i.e.  $\leq 0.2$  (extremely bearish), 0.4-0.6 (optimistic) and  $\geq 0.8$  (bullish). The quantile dependence between stock and respective bond indices in case of the USA show a relatively positive relation during extreme bearish and bullish market states in both markets. In the case of UK, Canada and Germany, the stock-bond dependence is positive for the majority of quantile combinations, except the areas which combine the lower quantile of stock ( $\leq 0.4$ ) with lower quantile of benchmark bonds ( $\leq 0.4$ ) and exhibited small negative dependence. However, in case of Japan when stock market is optimistic (0.4-0.6), negative dependence can be seen at upper quantiles with the benchmark bond. These findings suggest that flight to safety phenomenon is short-lived because of positive dependence between stock and benchmark bonds at various quantiles. This is in line with the conventional wisdom that common macroeconomic conditions, such as the expected inflation or economic prospects, drive both stock and bond markets (Jammazi et al. 2015; Bodart and Reding, 1999; Ilmanen, 2003). These observations suggest that benchmark bond indices of these countries are not perfect hedge in most of the quantiles. However, the bond market can act as a hedge for the stock investments in case of Japan. Interestingly, bonds may still be seen as safe havens for the stock market investors in the developed markets.

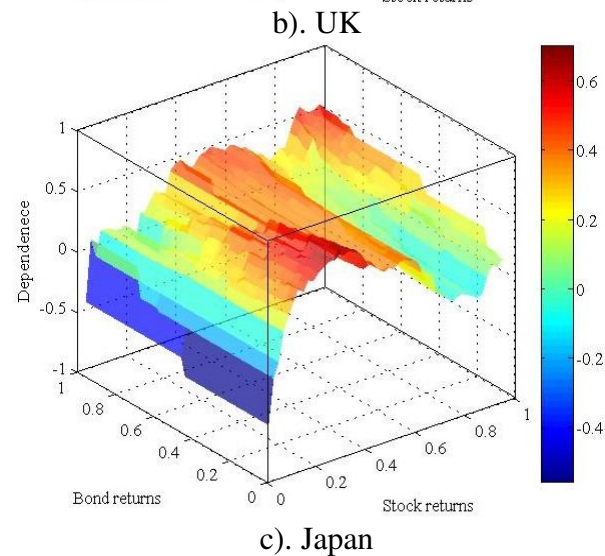
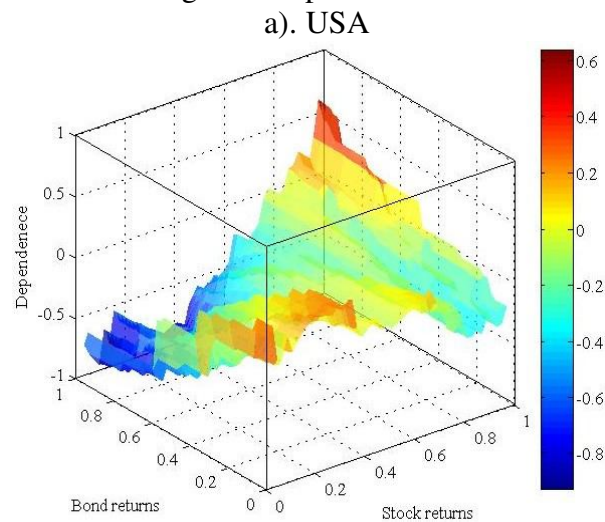
Furthermore, the GIPSI countries' benchmark bonds perform better than developed markets' bond indices in terms of diversification and safe havens. The bond indices of GIPSI markets exhibit weak or low dependence with stock markets at various quantiles and a strong negative dependence is evident in the lower quantile (i.e.  $\leq 0.4$  quantiles) of stock and bond indices.



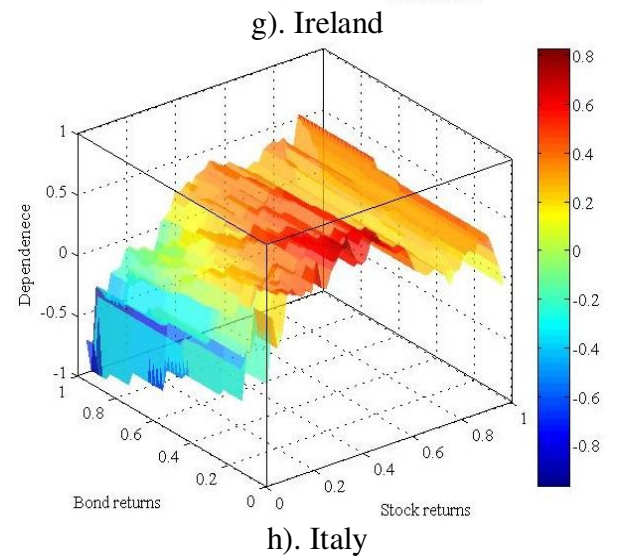
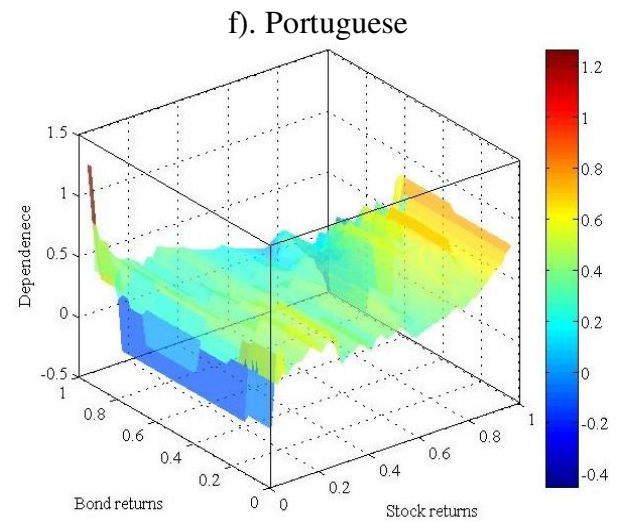
Interestingly, when both the markets are bearish, there is no evidence that negative shocks in stock markets can generate stress in the respective bond markets. However, at the middle quantiles (i.e. 0.4-0.6) i.e. normal market conditions, stock return shows strong positive dependence with the middle quantiles of the benchmark bonds.

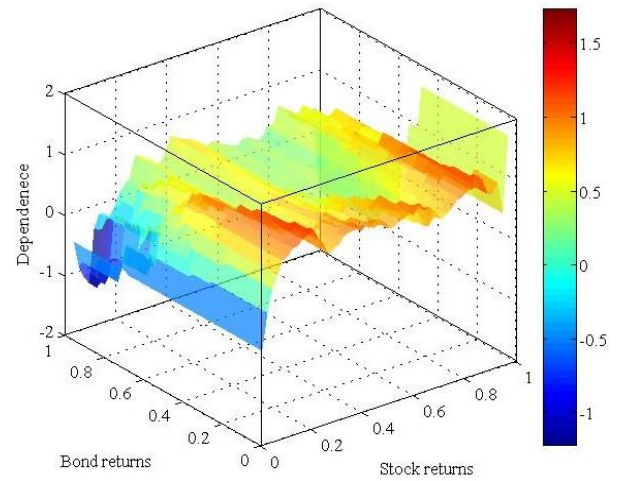
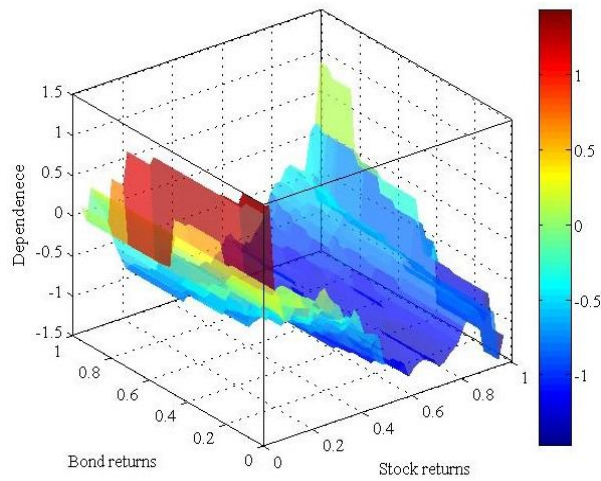
**Figure 3:** QQ estimates of the slope coefficient,  $\hat{\beta}_{(\theta,\tau)}$  : Stock returns (right) – Bond Returns (left)

**Panel A:** Large developed markets

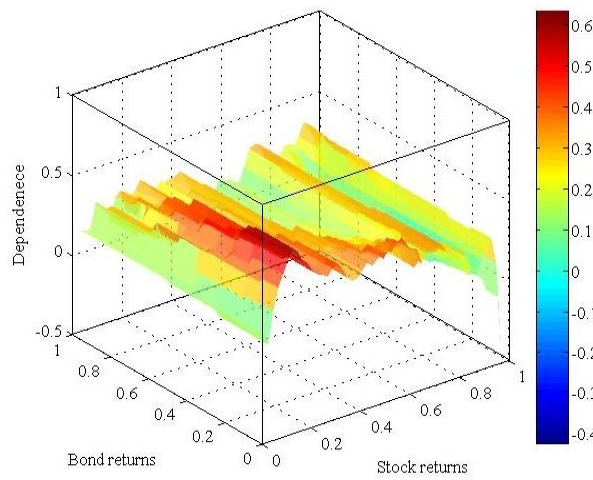


**Panel B:** GIPSI markets

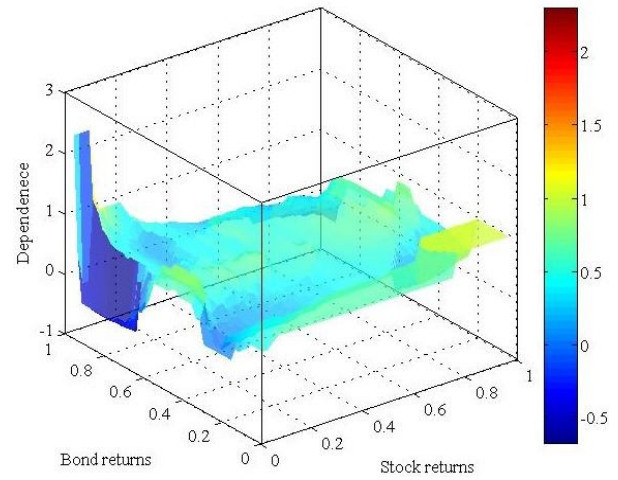




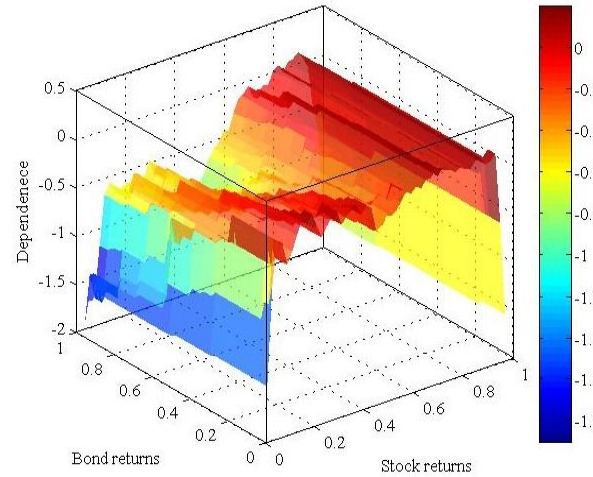
d). Canada



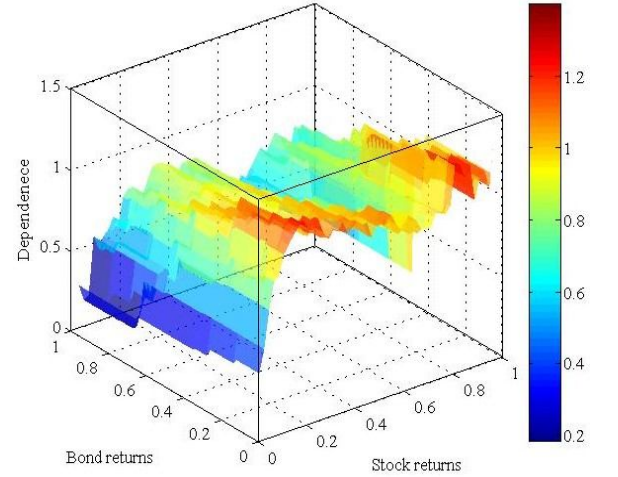
i). Greece



e). Germany



j). Spain





## 5.2. Validity of the QQ approach

The quantile on quantile (QQ) approach can be viewed as a method that decomposes the standard quantile regression model estimates to obtain specific estimates for the explanatory variable at different quantiles. In this study, the standard quantile regression model is used to regress the  $\theta$ th quantile of stock on  $\tau$ th quantile of gold/bond. As compared to standard quantile regression technique i.e. indexed by  $\theta$ , the QQ approach parameters are indexed by the both  $\theta$  and  $\tau$ . Thus, the QQ approach comprises more disaggregated information regarding the stock-gold and stock-bond dependence than the standard quantile regression model.

Given this property of decomposition inherent in the QQ approach, it is possible to use the QQ estimates to recover the estimates of the standard quantile regression. Specifically, the quantile regression parameters, which are only indexed by  $\theta$ , can be generated by averaging the QQ parameters along  $\tau$ . For example, the slope coefficient of the quantile regression model, which measures the dependence of gold/bond on the distribution of stock returns and is denoted by  $\gamma_1(\theta)$ , can be obtained as follows:

$$\gamma_1(\theta) \equiv \overline{\hat{\beta}_1}(\theta) = \frac{1}{S} \sum_{\tau} \hat{\beta}_1(\theta, \tau) \quad (6)$$

Where,  $S=49$  is the number of quantiles  $\tau = [0.02, 0.04, \dots, 0.98]$  considered.

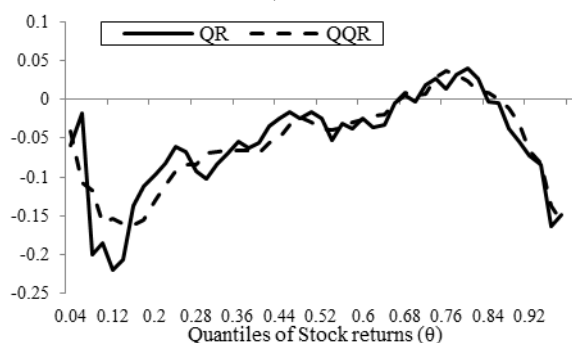
In order to check the validity of the QQ approach, the estimated parameters of standard quantile regression model are compared with the  $\tau$ -averaged QQ parameters. Thus, the averaged QQ and standard quantile regression estimates are displayed in Figures 4 and 5, for gold and bond, respectively. It is evident that the coefficient of QQ approach exerts similar pattern as can be seen from quantile regression estimates regardless of the quantile for all countries. This graphical

representation simply provides the validation of the QQ approach. Further, the primary features of the quantile regression model can also be recovered by summarizing the more detailed information contained in the QQ estimates. Our findings of QQ and QR estimates coincide with that of the slope coefficient presented in previous section. Figure 4 entirely confirms that the stock-gold relation is consistently negative across various quantiles for all countries. In fact, the positive association between stock and gold can only be seen for some quantiles for Japan and Ireland. In contrast to stock-gold relation Figure 5, largely confirms the positive dependence between benchmark bonds and stock markets at various quantiles, except, US, Japan and German bond.

**Figure 4:** Comparison of Quantile Regression and QQ estimates: Stock & Gold Returns

**Panel A: Large developed markets**

a). USA



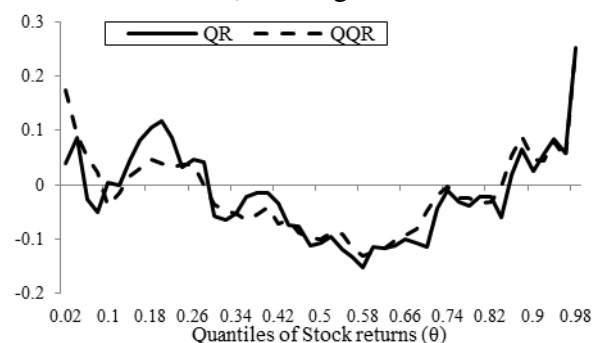
b). UK



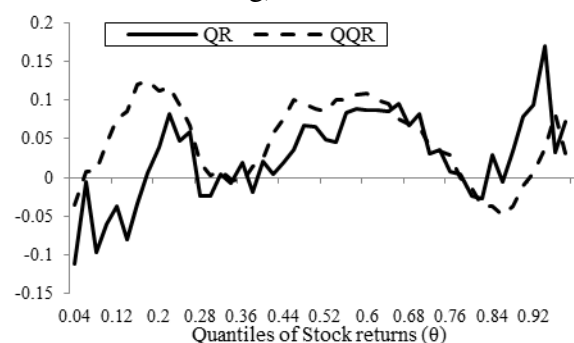
c). Japan

**Panel B: GIPSI markets**

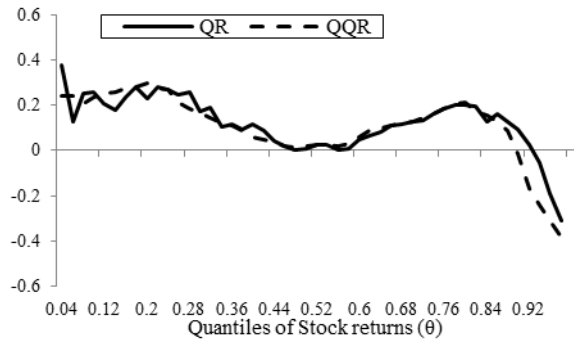
f). Portuguese



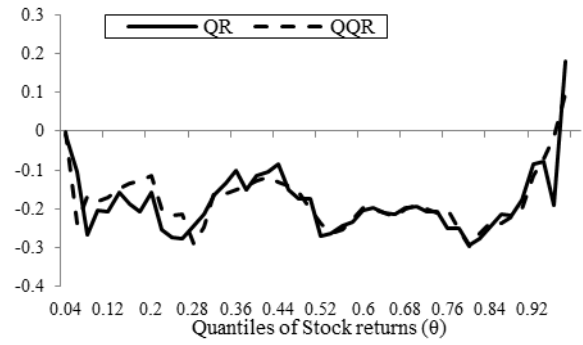
g). Ireland



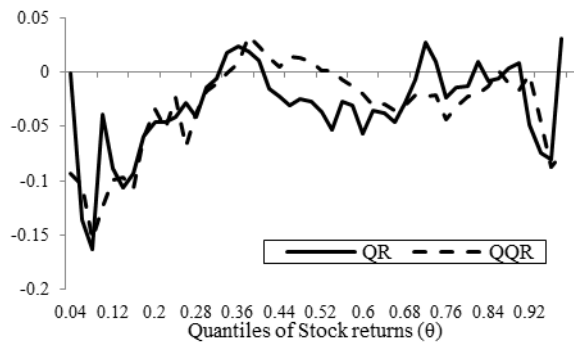
h). Italy



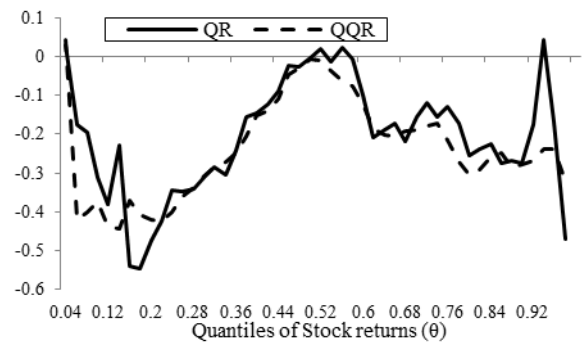
d). Canada



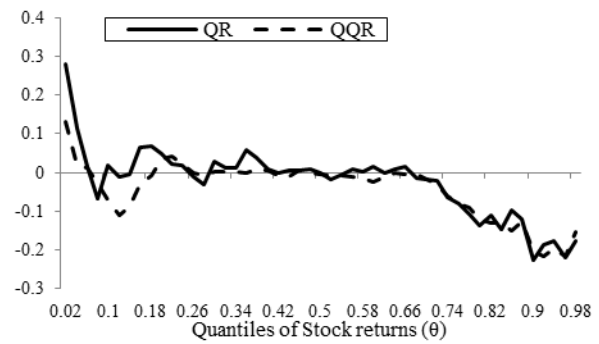
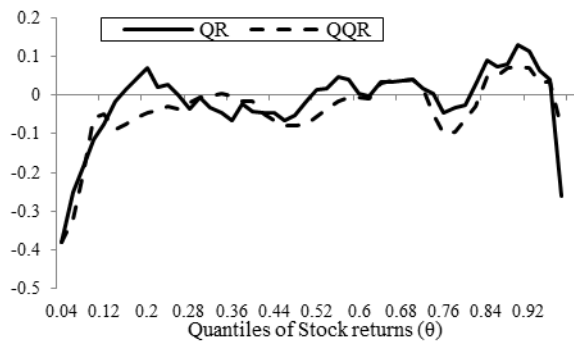
i). Greece



e). Germany



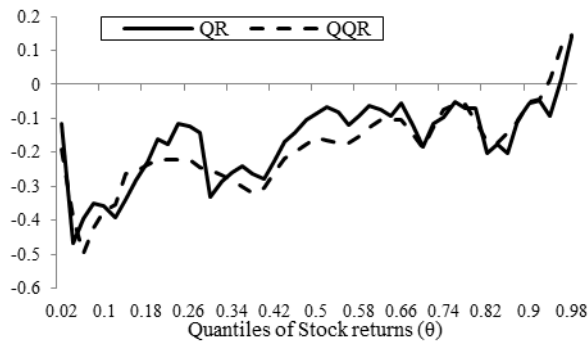
j). Spain



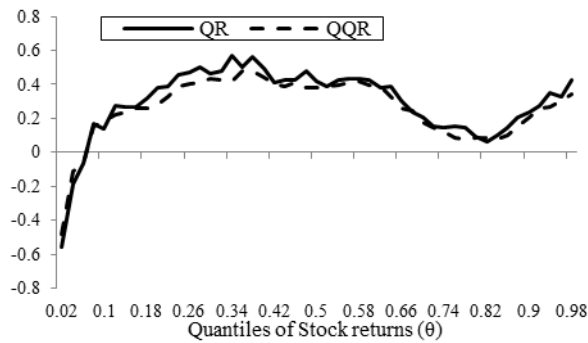
**Figure 5:** Comparison of Quantile Regression and QQ estimates: Stock & Bond Returns

**Panel A: Large developed markets**

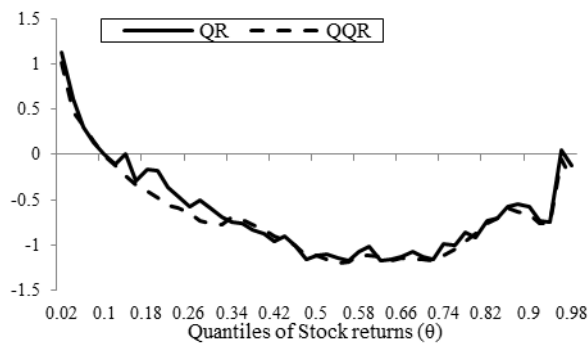
a). USA



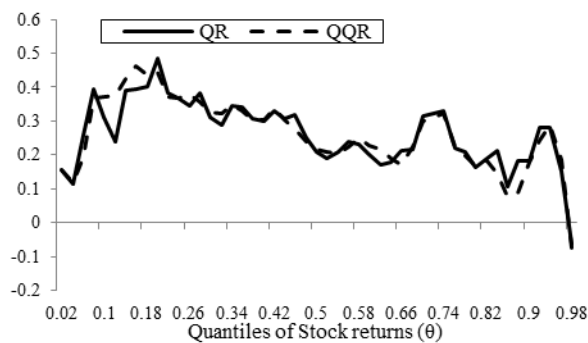
b). UK



c). Japan

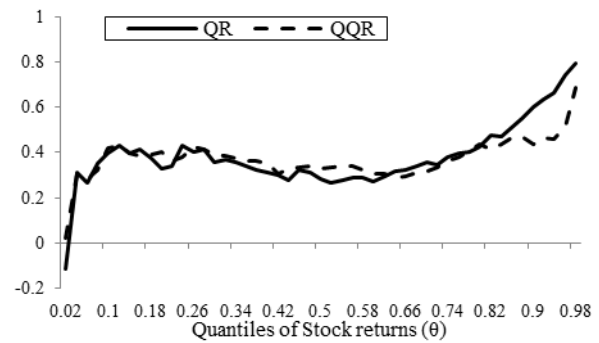


d). Canada

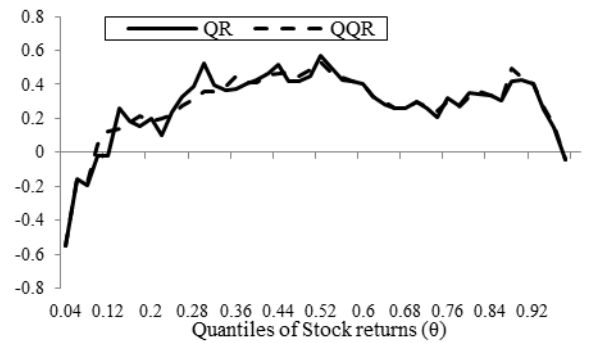


**Panel B: GIPSI markets**

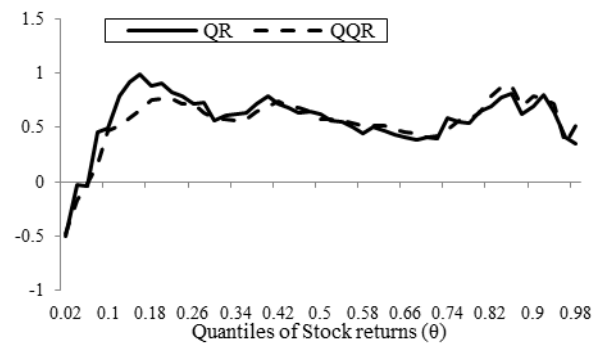
f). Portuguese



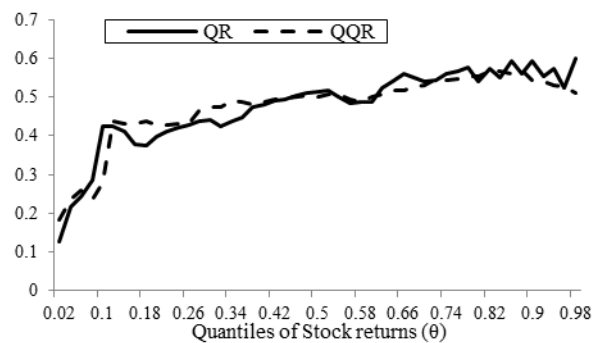
g). Ireland

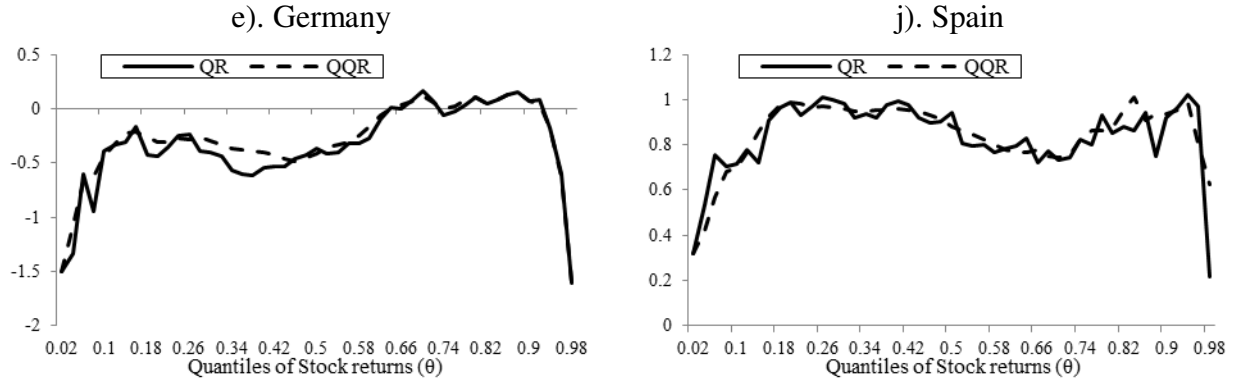


h). Italy



i). Greece





## 6. Conclusion

In this paper, we apply a relatively new estimation technique, dubbed as the QQ approach, to examine the hedging, diversification and safe haven properties of gold and bonds for selected developed and GIPSI stock markets. The key advantage of the QQ approach is its ability to model dependence structure (economic relationships) in its entirety compared to the naïve techniques such as OLS and standard quantile regression.

Overall, several interesting findings emerge. First, gold exhibits negative dependence with major stock markets like USA, UK, Japan, Canada and Germany for majority of the market states. This low or negative dependence implies that gold is strong hedge and diversifier during normal and bullish market conditions. This unique characteristic of gold makes it very appealing hedging tool and useful as part of an investment portfolio. In case of peripheral Eurozone equity markets (i.e. GIPSI) countries, gold lacks hedging ability only during extreme bearish market conditions, but at intermediate to upper quantiles gold served its traditional role as diversifier assets. Interestingly, when both stock and gold markets are pessimistic i.e. extreme lower quantiles, gold shows positive dependence with stock markets and hence may not act as a safe haven. Second, despite the prevailing positive connection between benchmark bonds and respective

stock indices, there is a considerable heterogeneity across various quantiles. This may be attributed to the significant differences in stock-bond relation in different market conditions. It is also worth mentioning that ignoring the stock-bond dependence could lead to lower diversification benefits. Thirdly, in each country, sizeable variations of the slope coefficient are observed for both gold and bond across different quantiles. These findings suggest that dependence between stock-gold and stock-bond is not uniform, but this relationship is market (e.g. bearish, mild bearish, optimistic or bullish) and country specific.

The change in dependence of gold with stock markets across different market states may be attributed to their currency market situations, level of economic growth, interest rate, inflation and unique local investment settings. For instance, an economy experiencing high inflation along with growing GDP may experience both rising gold and stocks i.e. stock rise due to FDI infusion and gold rises because of inflation. In such an economy, a positive shock in gold prices, given that interest rate is low, make it easy to choose gold as an alternative to bonds or stocks and other fixed-income investments.

Our findings have important implications for investors and policy makers to understand the dependence dynamics of hedge assets i.e. gold and bonds as the contagious effects of the recent global financial crisis and Eurozone crisis have forced the stock market investors to seek hedging, diversification, and particularly the safe haven opportunities. During normal and bullish market states (middle to upper quantiles), gold can provide protection against downside price risk through hedging and diversifies the stock portfolio risk. However, the change in dependence structure across varying market states require special attention from the investors as one should re-balance the portfolios with the changing market states to take benefits of hedging/diversification properties of gold. It is worth mentioning that gold and stock are

positively linked when both the markets are under stress and thus a portfolio may suffer extreme losses in time when both the assets are on their downturn. A sudden negative spike in the stock returns will quickly transmit to the gold markets. This unique characteristic of gold-stock dependence has recently been confirmed by Bekiros et al. (2017) using wavelet and copula analysis for BRICS stock markets. Finally, the negative dependence between bonds and stock during bearish states, though short-lived, may be considered as an opportunity to hedge price risk of stock portfolios especially by the GIPSI market investors.

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