

Volume 39, Issue 2

Nonlinear and extreme dependence between long-term sovereign bond yields and the stock market: A quantile-on-quantile analysis

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Abstract

This paper explores the links between yields on long-term bonds and stock market returns using the novel quantile-on-quantile (QQ) method. This approach quantifies the effect that the quantiles of bonds yield have on the quantiles of stock returns, thus offering a suitable framework for capturing the entire dependence structure. The empirical results illustrate that the interest rate-equity market nexus is principally positive. In fact, the most pronounced relationship is detected under extreme circumstances in both stock and sovereign bond markets, mainly in an environment characterized by sharp declines in yields on 10-year Treasury bonds and a markedly bearish environment in stock prices. The findings of this study have significant implications for practitioners in making adequate asset allocation and hedging decisions and also help policy makers to preserve financial stability, particularly in times of heightened uncertainty and financial crisis.

Citation: Román Ferrer and Syed Jawad Hussain Shahzad and Adrián Maizonada, (2019) "Nonlinear and extreme dependence between long-term sovereign bond yields and the stock market: A quantile-on-quantile analysis", *Economics Bulletin*, Volume 39, Issue 2, pages 969-981

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Submitted: January 03, 2019. **Published:** April 27, 2019.

1. Introduction

Interest rates and stock returns constitute two key macro finance variables that are indissolubly linked in modern finance. The relationship between interest rates and stock prices is well established at the theoretical level by standard equity valuation models. The price of a common stock is simply the present value of all the expected future cash flows earned on that stock discounted at an adequate discount rate (Williams, 1938). In this context, there are various channels through which interest rates can influence share prices. First, movements in interest rates are expected to move the discount rate in the same direction via their effect on the nominal risk-free interest rate. Second, interest rate fluctuations may notably alter the corporate financing costs, mainly for firms facing heavy debt loads. The amount of debt servicing expenses of these companies will suffer significant modifications following changes in interest rates, which will impact future corporate earnings and cash flows and, hence, equity prices. Third, changes in interest rates can also affect share prices through the substitution effect. Rising interest rates raise the relative attractiveness of investing in fixed income securities, encouraging investors to switch their money from stocks to bonds. These portfolio rebalancing strategies result in a decline in the demand for stocks, thus depressing equity prices. Similarly, the performance of the stock market can also exhibit a remarkable influence on developments in interest rates. For example, given the forward-looking nature of the stock market, a sharp decline in stock prices can be taken as a sign of weakness for the economy in the future, which eventually can translate into falling interest rates in an attempt to boost the economy. In this regard, the survey evidence among U.S. CFOs by Graham and Harvey (2001) suggests that interest rate risk represents the second most important financial risk, just after credit risk.

The interest rate-equity market nexus is a classical topic in finance and, therefore, has been the subject of a long debate. Most empirical studies addressing this issue are based on conditional mean estimation techniques such as OLS regression and cointegration and Granger causality. Nonetheless, there are some complexities in the linkage between movements in interest rates and equity returns that go beyond the scope of these traditional methods. For instance, the impact of large fluctuations in interest rates on the stock market can be substantially different from the impact caused by small interest rate variations. Likewise, stock returns can respond asymmetrically to rises and falls in interest rates. The quantile-on-quantile (QQ, hereafter) methodology introduced by Sim and Zhou (2015) appears as a suitable framework because it makes it possible to describe the entire pattern of dependence between two asset returns through the dependence between their quantiles.

The main contribution of this paper to the extant literature is that it offers an alternative setting to assess the interest rate-stock market link based on the novel QQ methodology of Sim and Zhou (2015). The QQ approach not only captures the heterogeneous association between stock returns and interest rate variations at distinct points of the conditional distribution of stock returns, as the standard quantile regression does, but it also models the quantile of stock returns as a function of the quantile of interest rate movements. Therefore, the QQ framework enables the linkage between movements in interest rates and stock returns to be conditional on the stock market cycle and the size and/or sign of interest rate shocks.

Two key empirical results emerge from this paper. First, the interest rate-equity market nexus takes positive values for most combinations of quantiles of changes in 10-year sovereign bond yields and stock returns in the majority of countries. However, it is worth highlighting that a number of countries in the periphery of the euro area, namely Greece, Ireland, Portugal, Italy and Spain, which were severely hit by the recent European sovereign debt crisis, exhibit a weak and predominantly negative link between movements in 10-year Treasury yields and equity returns. A possible explanation for this singular behavior is that, since the outset of the global

financial crisis and particularly the Eurozone debt crisis, the stock markets of these peripheral countries have been largely driven by the pessimistic economic prospects, while interest rates have played a minor role. Second, our quantile-based analysis also reveals that the relationship between changes in yields on 10-year Treasury bonds and stock returns does not remain stable across quantiles, but it is dependent on both the nature of interest rate fluctuations and the cycle of the stock market. Thus, for many countries this linkage is especially pronounced under extreme scenarios in stock and government bond markets and, mainly, during periods of sharp decreases in long-term interest rates and markedly bearish performance of the equity market. These findings imply that market participants should be very aware of the specific conditions in equity and bond markets in order to implement effective allocation and hedging strategies as well as to preserve financial stability, particularly in time of financial turmoil.

2. Review of literature

A vast body of literature on the relationship between movements in interest rates and equity returns has proliferated over the last few decades (Flannery and James, 1984; Reilly et al., 2007; Akhtaruzzaman and Shamsuddin, 2017). Much of this research has focused on the banking industry due to the peculiar nature of the financial intermediation business as a large proportion of banks' income and costs are directly dependent on interest rates. Banking institutions generally borrow short-term deposits and make long-term loans. The resulting maturity mismatch or duration gap, i.e., the difference between the average duration of banks' assets and the average duration of banks' liabilities, is commonly cited as the key reason for the high level of interest rate exposure of banking firms (Flannery and James, 1984; Staikouras, 2003). The positive duration gap is expected to cause rising interest rates to have a detrimental impact on the value of banks, while interest rate falls will have the opposite effect. In particular, increases in interest rates cause the loss of value of bank assets to be greater than that of bank liabilities, thus reducing the net worth of banks. There is also an income-statement effect because interest rate hikes lead to a faster growth in the cost of bank liabilities than in the revenues of bank assets, resulting in a shrink of bank margins. Nevertheless, share prices of nonfinancial companies can be also significantly sensitive to interest rates (Bartram, 2002; Moya-Martínez et al., 2015). This influence manifests through the effect of changes in interest rates on the cost of capital, the debt service expenses and the cash flows of indebted firms as well as on the market value of financial assets and liabilities of nonfinancial corporations.

All the aforementioned channels imply an inverse relationship between changes in interest rates and firms' equity returns. Nonetheless, a positive interest rate-stock market linkage can be also justified on the basis of economic growth prospects. This is because interest rates and equity prices can behave in the same way in response to expectations about the state of the economy. For instance, rising interest rates in a country may be perceived by economic agents as an evident sign of strengthening economic activity and stronger business performance, with the concomitant positive impact on the stock market of that country. Conversely, interest rate drops may be viewed as signaling a weaker economy, which will adversely affect share prices.

Until now, the empirical work on the interest rate-stock market association has been mostly carried out in the time domain using a wide variety of time series techniques that vary enormously in complexity, scope and aim. They include from standard linear regression analysis (Flannery and James, 1984; Sweeney and Warga, 1986) to more sophisticated approaches such as Generalized autoregressive conditional heteroscedasticity (GARCH)-type models (Elyasiani and Mansur, 1998; Kasman et al., 2011;), Vector autoregression (VAR) systems (Lee, 1992; Ozcelebi and Yildirim, 2017), cointegration techniques (Chan et al., 1997; Musawa and Mwaanga, 2017), Granger causality tests (Tamakoshi and Hamori, 2014; Jammazi et al., 2017) or even nonlinear models (Bartram, 2002; Ballester et al., 2011).

Despite the use of different countries, sample periods, interest rate series and empirical methodologies, most of these studies identify a significantly negative association between interest rate changes and stock returns of financial and nonfinancial firms (Lyngne and Zumwalt, 1980; Elyasiani and Mansur, 1998; Nissim and Penman, 2003). Among nonfinancial corporations, Utilities are regarded as the companies most strongly exposed to interest rate risk principally due to their high indebtedness and regulated nature (Sweeney and Warga, 1986; Reilly et al., 2007). Meanwhile, several recent contributions, including those of Korkeamäki (2011) and Délèze and Korkeamäki (2018), show that corporate interest rate exposure varies considerably over time. They find that the interest rate sensitivity has followed a firmly declining trend over the past years, primarily owing to the increasing availability of tools that allow firms to manage better their interest rate risk. More precisely, the extraordinary development of the market of interest rate derivatives, along with the deeper European corporate bond markets after the euro's launch in 1999, may have played a central role in this transformation. Further, as evidenced by Bartram (2002) and Korkeamäki (2011), stock returns are generally more responsive to movements in long-term interest rates than to short-term rates. There is also a rapidly growing strand of research that addresses this topic in the time-frequency space through wavelet analysis (Kim and In, 2007; Ferrer et al., 2016; Bayraci et al., 2018). These wavelet-based studies find that the interest rate-stock market nexus relies heavily on the time scale considered and become higher at longer investment horizons.

A critical feature shared by the aforementioned empirical works is that they all examine mean and/or variance effects in the connection between sovereign bond yields and stock returns, which could lead to the underestimation of the real link between both variables. In contrast, Jareño et al. (2016), Ferrando et al. (2017) and Umar et al. (2018) are, so far, the only contributions that have addressed this issue paying special attention to the effect of interest rate changes on stock returns under different equity market scenarios, i.e. bullish, bearish or relatively calm states. Using quantile regression methods, these papers find that the interest rate exposure of the US, Spanish and Islamic equities at the industry level, respectively, is more intense during extremely bearish or bullish episodes in the stock market. However, it is worth highlighting that no prior study has analyzed the interest rate-equity market nexus by considering all quantiles of the distributions of interest rate fluctuations and stock returns.

3. Data and methodology

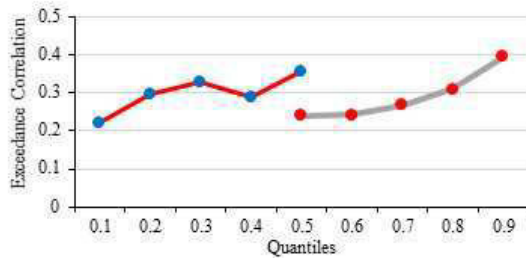
Our dataset is composed of stock market indices and yields on 10-year sovereign bonds for fourteen developed countries that can be grouped into four categories: (1) Countries within the core of the euro area (Germany, France, Netherlands and Belgium); (2) Countries in the periphery of the Eurozone (Italy, Spain, Portugal, Greece and Ireland); (3) Two European non-Eurozone countries (the UK and Norway); (4) Three major non-European countries (the US, Japan and Australia). The sample period ranges from January 2001 to March 2016. Daily data are employed in this study (totaling 3985 daily observations). Natural logarithmic returns are used for the empirical analysis. All the data are sourced from Thomson Reuters Datastream.

To gain some preliminary insight into the presence of a nonlinear relation between changes in yields on 10-year Treasuries and stock returns, the concept of exceedance correlation proposed by Longin and Solnik (2001) is used. The basic intuition behind this indicator is to calculate the correlation between two time series, conditioning on that both series lie jointly above or below a given percentile of their empirical cumulative distribution functions. In other words, the exceedance correlation allows estimating the contemporaneous correlation for any quantile value of the two variables involved. Figure 1 depicts the exceedance correlations between 10-year Treasury bond yield movements and equity returns at different quantiles for each country.

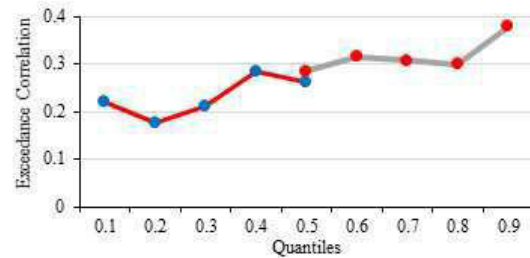
It is shown that the exceedance correlation estimates vary substantially across quantiles, although this indicator has positive sign for most pairs of quantiles in each country. The exceedance correlation does not follow a consistently increasing or declining pattern, but the interest rate-stock market correlation tends to differ greatly between the median quantiles and the extreme quantiles for the vast majority of nations. This finding suggests that the linkage between 10-year sovereign bond yield variations and stock returns is not strictly linear and, therefore, quantile methods emerge as a promising alternative to capture this nonlinearity.

Figure 1. Exceedance correlations between changes in 10-year bond yields and stock returns

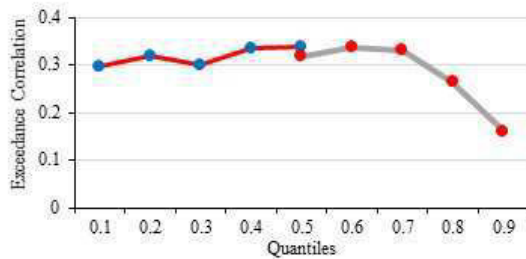
a) Australia



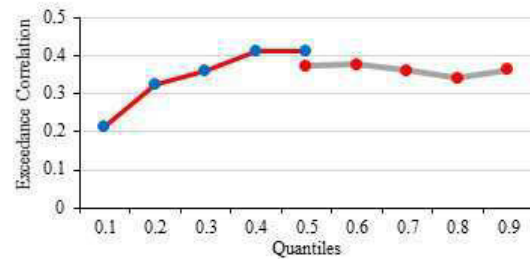
b) Belgium



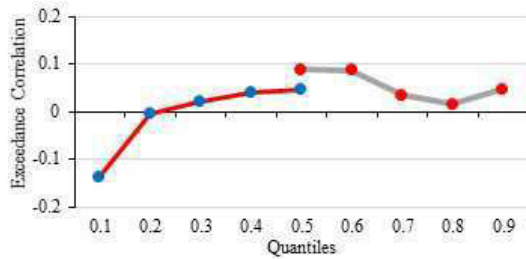
c) France



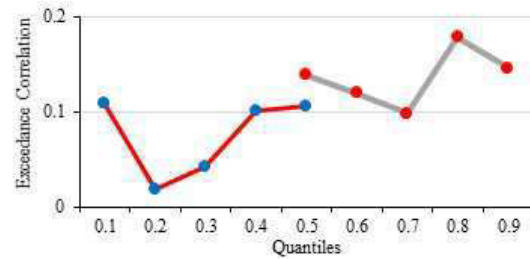
d) Germany



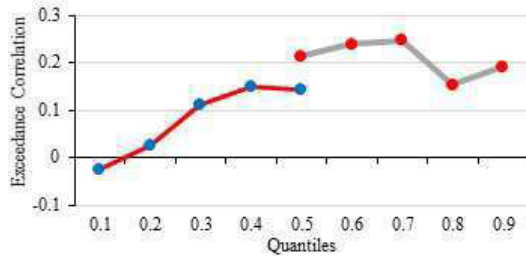
e) Greece



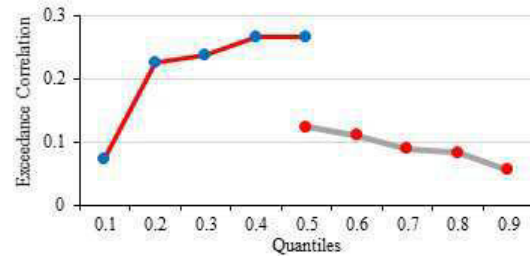
f) Ireland



g) Italy

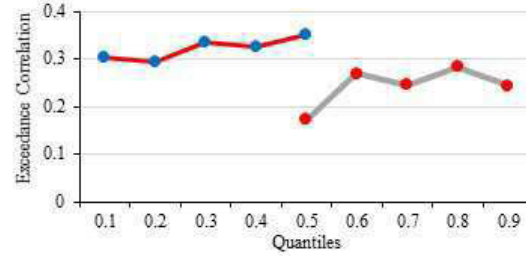
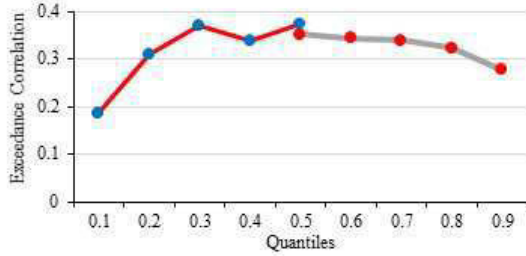


h) Japan



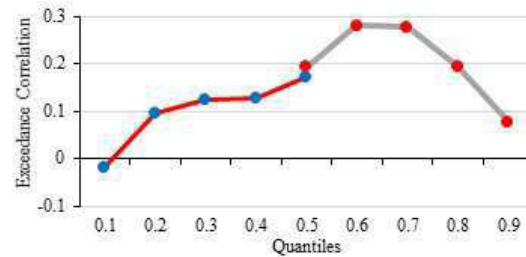
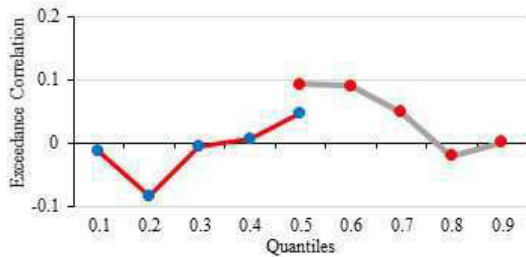
i) Netherlands

j) Norway



k) Portugal

l) Spain



m) UK

n) USA

Notes: This figure plots the exceedance correlation between changes in 10-year government bond yields and stock returns for different quantiles of both variables in each country under examination. The left-tail exceedance correlations ρ_{τ}^{-} are represented by the solid red line, while the right-tail exceedance correlations ρ_{τ}^{+} are represented by the grey solid line.

In what follows, we describe the main features of the QQ approach of Sim and Zhou (2015), although the mathematical details of the QQ method can be found in the online appendix.¹ OLS regression is undoubtedly the most common technique to quantify the relationship among a set of variables, although it only estimates the mean value of a response variable for given levels of explanatory variables. This means that OLS is well suited for describing the central tendency of the data, but it is not efficient when the dependent variable follows a non-normal distribution, with properties such as asymmetry, volatility clustering and fat tails, which are very usual in financial data. Meanwhile, the quantile regression method proposed by Koenker and Bassett (1978) is more powerful than standard OLS since it allows modeling the relationship between a response variable and several explanatory variables for the full conditional distribution of the response variable. Moreover, quantile regression estimators are more efficient than OLS estimators under violations of the typical assumptions in linear regression.

In addition, the QQ approach was introduced by Sim and Zhou (2015) as a generalization of the quantile regression that models the quantiles of a variable as a function of the quantiles of another variable. This implies that the relationship between the two involved variables can be different at each point of the respective distributions. In essence, the QQ integrates quantile regression and nonparametric estimation methods in a single equation regression framework and its implementation can be split into two steps. First, the quantile regression approach enables identifying the differential impact of an explanatory variable on the response variable

¹ The R code used for application is attached to this article.

at any arbitrary point of the conditional distribution of the response variable. Second, local linear regression allows estimating the local effect of a particular quantile of an explanatory variable on the response variable. Local linear regression originally proposed by Stone (1977) prevents the “curse of dimensionality” problem that typically affects nonparametric methods.² This dimension reduction process fits locally a linear regression in the neighborhood of each sample point, assigning greater weight to observations closer to the focal point through an appropriate kernel function. Therefore, this combination of methods permits assessing the linkage between the response variable and an explanatory variable from a novel quantile-on-quantile perspective, i.e. at each quantile of the distribution of the two variables, thus giving a more comprehensive and realistic picture than more traditional approaches.

4. Empirical application

This section presents the main findings of the application of the QQ approach between changes in 10-year sovereign bond yields and equity returns for the fourteen countries under analysis over the full sample. Figure 2 (a-n) plots the estimates of the slope coefficient, $\hat{\beta}_1(\theta, \tau)$, which quantifies the impact of the τ th quantile of 10-year government bond yield fluctuations on the θ th quantile of stock returns in each country, for a wide range of combinations of both variables. The slope coefficient estimates are depicted on the z-axis, while the quantiles of stock returns and 10-year Treasury rate movements lie on the x- and y-axes, respectively. A grid of 19 quantiles ranging from 0.05 to 0.95 with a step of 0.05 are considered for each variable. Thus, the QQ approach provides a more complete and reliable description of the dependence structure between 10-year Treasury bond yields and the equity market.

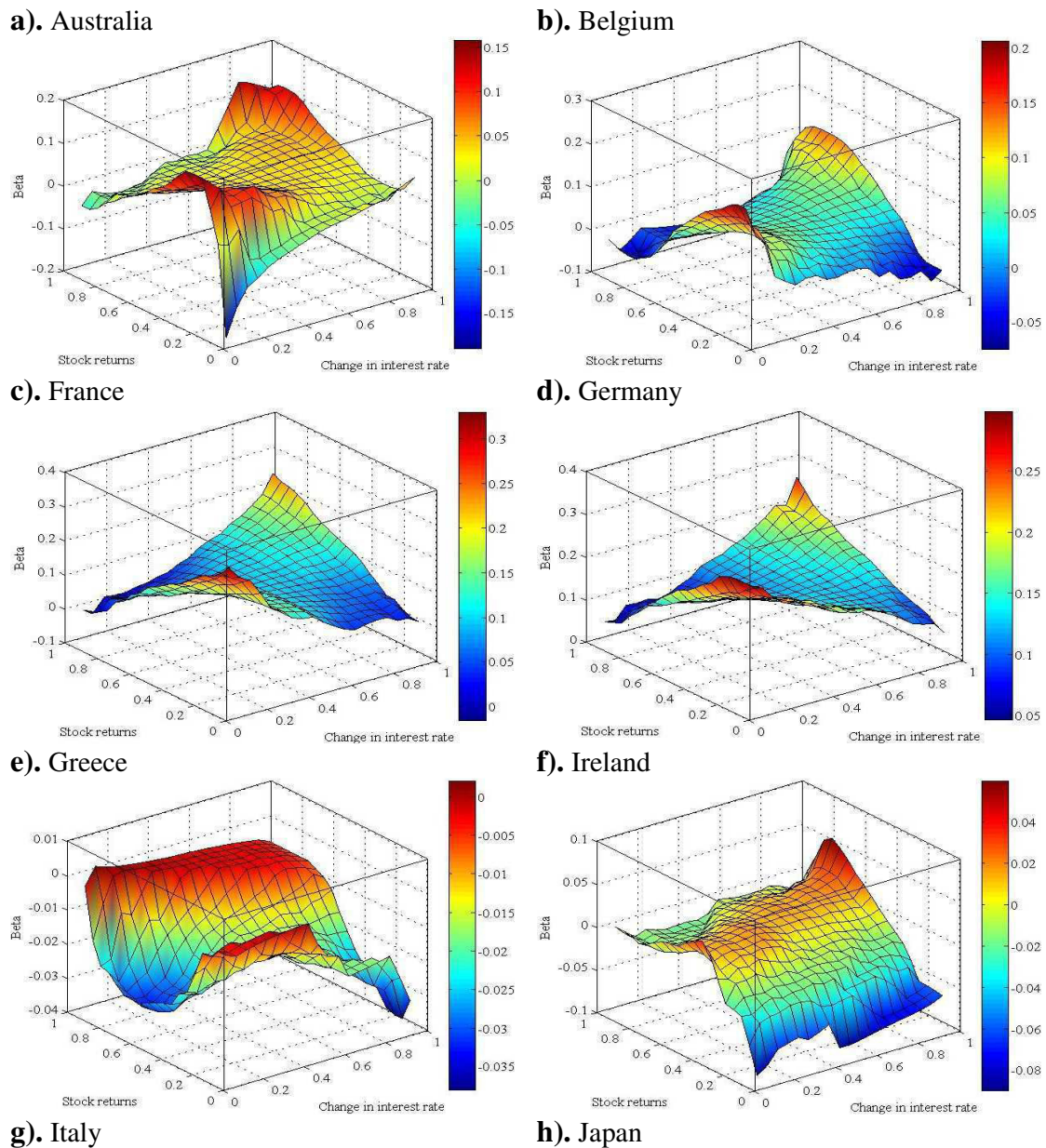
A number of relevant results are derived from plots in Figure 2. First, the interest rate-stock market association is primarily positive in the majority of countries. More precisely, the slope estimates take positive values for most combinations of quantiles of changes in 10-year interest rates and stock returns in Australia, Belgium, France, Germany, Japan, the Netherlands, Norway, the UK and the US. However, the link between quantiles of 10-year Treasury bond yield movements and equity returns is predominantly negative for a group of euro area’s peripheral countries, such as Greece, Ireland, Italy, Portugal and Spain. Second, the slope coefficient estimates fluctuate considerably depending on the specific quantiles of changes in 10-year Treasury bond yields and stock returns. This finding means that the interest rate-equity market nexus is not homogeneous among quantiles, but it is dependent on the sign and the size of interest rate shocks and the situation of the equity market in each country.

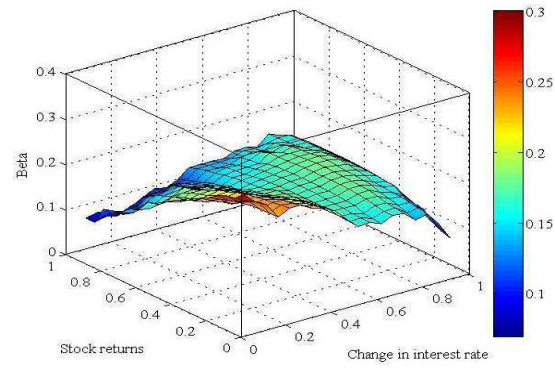
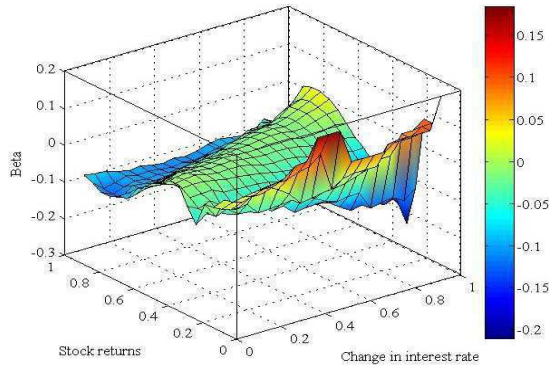
Overall, the interest rate-equity market relationship tends to be rather small as there are large areas of the distributions of stock returns and 10-year sovereign bond yield variations in which these two variables appear to be uncoupled. However, the strongest (in absolute value) link between 10-year Treasury bond yield changes and equity returns is observed for most countries under extreme circumstances in both stock and government bond markets. Specifically, the most meaningful interest rate-stock market association tends to be found in the region that combines the lowest quantiles of changes in yields on 10-year Treasuries (0.05-0.10) with the lowest quantiles of stock returns (0.05-0.10). This result suggests that the most intense linkage manifests itself during periods of intense falls in long-term interest rates and extremely bearish equity market performance. This supports the widespread view that interactions between financial market returns are amplified in times of strong bear markets and financial crises due to the emergence of financial contagion effects (Campbell et al., 2002; Cappiello et al., 2006).

² The curse of dimensionality is the widely observed phenomenon that data analysis techniques in general and nonparametric methods in particular work poorly as the dimensionality of the analyzed system grows. This is principally due to the slow convergence of nonparametric estimators when additional regressors are included.

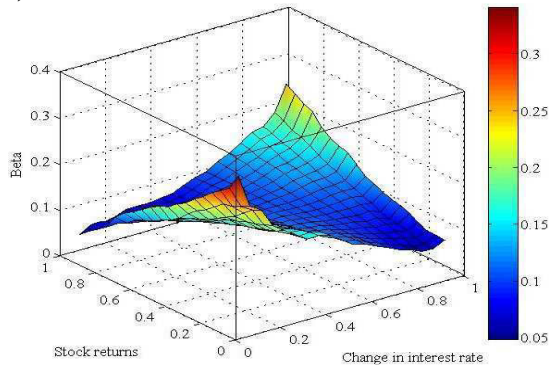
Looking at the results by country, Belgium, France, Germany, Japan, the Netherlands, Norway, the UK and the US show a very similar pattern of connection between variations in 10-year Treasury bond yields and stock returns. The interest rate-equity market relationship in these countries takes positive values for most combinations of quantiles of both variables. The highest values of the slope estimates are reached in the region that couples the lowest quantiles of long-term interest rate changes (0.05-0.10) with the lowest quantiles of stock returns (0.05-0.10). This finding implies that sharp 10-year sovereign bond yield cuts tend to strengthen the fall in stock prices under acute bearish episodes in the stock market. One plausible explanation for this is that dramatic drops in 10-year interest rates during a markedly bearish stock market scenario are interpreted by market participants as an unequivocal symptom of deterioration of the economy of the country, which further exacerbates the decline in the stock market.

Figure 2. Quantile-on-Quantile (QQ) estimates.

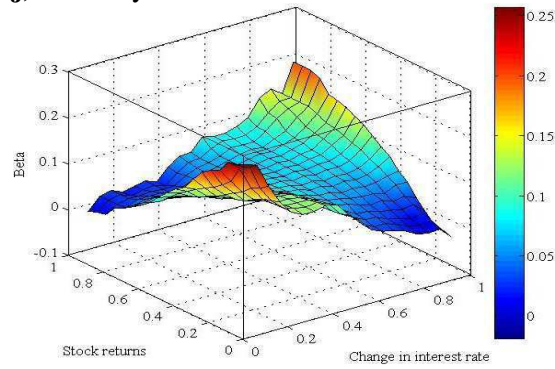




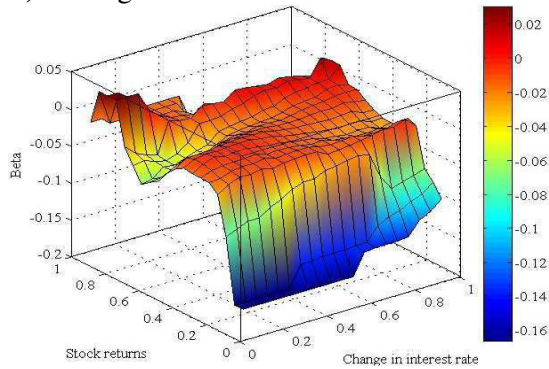
i). Netherlands



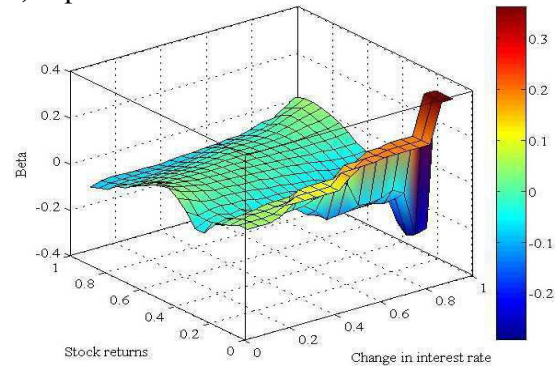
j). Norway



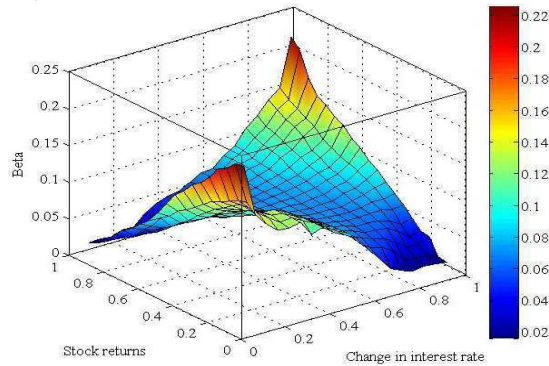
k). Portugal



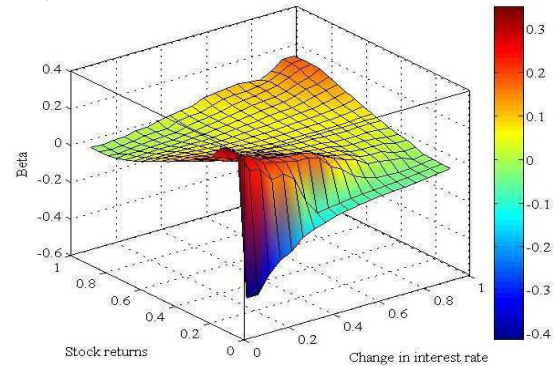
l). Spain



m). UK



n). USA



Notes: The graphs show the estimates of the slope coefficient, $\hat{\beta}_1(\theta, \tau)$, in the z-axis against the quantiles of stock market returns (θ) in the x-axis and the quantiles of changes in 10-year government bond yields (τ) in the y-axis, for the full sample period (from January 2001 to March 2016).

In contrast, as mentioned above, a number of Eurozone peripheral countries which were badly affected by the sovereign debt crisis that began in late 2009, i.e. Greece, Ireland, Italy, Portugal and Spain, are characterized by a mainly negative link between 10-year Treasury bond yield movements and stock returns. However, there is significant heterogeneity among these countries in terms of the interest rate-equity market association. For example, Greece emerges as the country with the weakest connection between 10-year sovereign bond yield variations and stock returns. The largest (in absolute value) slope estimates in the Greek case only take values around -0.038 and are found in the region that combines the highest quantile of 10-year Treasury bond rate changes (0.95) and the lowest quantiles of stock returns (0.10-0.15). This implies that strong rises in 10-year interest rates involving a substantial increase in the cost of financing for Greek companies further accentuate the fall in the Greek equity market in a scenario of extreme bearish stock market performance. The limited interest rate-equity market relationship in Greece may be attributed to that, following the deepening of the worldwide financial crisis in autumn of 2008 and mainly since the eruption of the Eurozone debt crisis at the end of 2009, the Greek stock market has been fundamentally driven by the pessimistic outlook on Greece's economic prospects. The conjunction of the financial turmoil triggered by the latest financial crisis and the associated economic contraction, the structural weaknesses of the Greek economy (unsustainable levels of public debt and budget deficit), and the revelations about falsified statistical data by the Greek government led to a deep concern of investors regarding the ability of Greece to service its debt. Lastly, Greece received three bailout programs from the Eurozone states together with the International Monetary Fund in 2010, 2012 and 2015, respectively. Meanwhile, 10-year Treasury bond yields appear to have only played a very minor role in explaining the Greek stock market performance in comparison with that of the deteriorating macroeconomic fundamentals.

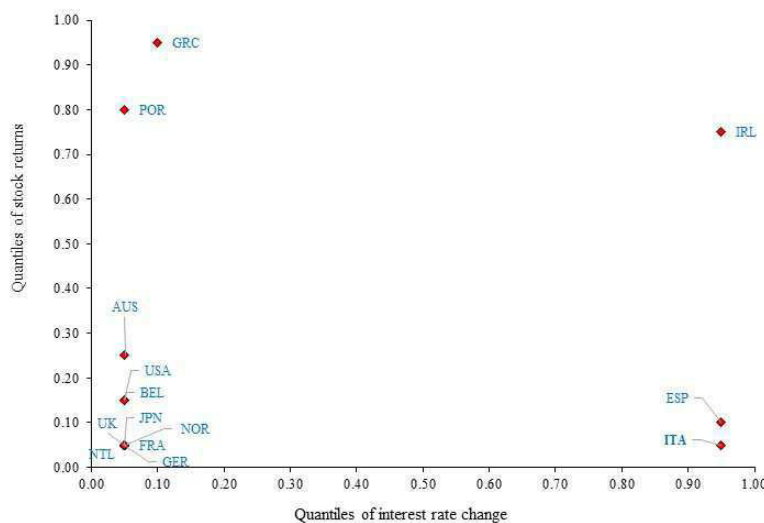
In turn, the interest rate-stock market nexus exhibits a common pattern in Ireland and Portugal. The linkage is mostly negative and small in magnitude for both countries and its peaks are reached in the area that combines the lowest quantiles of changes in yields on 10-year Treasuries (0.05-0.15) with the lowest quantiles of equity returns (0.05-0.10). This indicates that large drops in 10-year sovereign bond yields exert a beneficial influence on the Irish and Portuguese stock markets in situations of acute bearish stock market performance. A possible explanation for this finding is that substantial declines in long-term government bond yields entail a drastic fall in the cost of corporate borrowing, thus cushioning the stock market downturn. The weak interest rate-equity market link for Greece, Ireland and Portugal is largely consistent with the evidence provided for these same countries by Ferrer et al. (2016) based on wavelet analysis. These authors claim this result may have its origin in the severe impact of the recent worldwide financial crisis and the resulting debt crisis as well as the thin trading and small stock market capitalization in these Eurozone peripheral countries.

For Spain, the relationship between 10-year government bond yield changes and stock returns is also primarily negative. However, the most intense linkage is positive, takes higher absolute values than in the above mentioned nations and is located in the region that blends the largest quantiles of 10-year interest rate variations (0.90-0.95) with the lowest quantiles of equity returns (0.05-0.15). This means that strong rises in Spanish 10-year Treasury yields seem to have a beneficial effect on the Spanish stock market under acute bearish equity market conditions. A plausible explanation for this result is that large increases in 10-year sovereign bond yields are perceived by market participants as a signal of improvement in the Spanish economic outlook, which contributes to reduce the decline in the equity market. Lastly, in the Italian case the interest rate-stock market association is also overwhelmingly negative with higher absolute values than for Greece, Ireland and Portugal. The most meaningful negative link (in absolute value) is found in the area that couples the largest quantiles of interest rate

fluctuations (0.95) and the low to intermediate quantiles of stock returns (0.25-0.30). This suggests that extreme hikes in 10-year Italian Treasury rates tend to accentuate the fall in the Italian equity market during periods of mildly downward trend in stock prices. This result may be due to that strong increases in Italian 10-year interest rates imply a substantial rise in the cost of financing for Italian firms, which is interpreted as bad news and further boosts the decline in the Italian stock market. The relatively stronger linkage between 10-year Treasury bond yields and equity returns for Spain and Italy may be linked to the greater relative prominence of the sectors with high interest rate sensitivity (i.e. Utilities and Banking) in the Spanish and Italian equity markets as compared to the Greek, Irish and Portuguese markets. To sum up, the weak and predominantly negative connection between 10-year Treasury bond yield changes and equity returns for the countries of the periphery of the euro area may be attributed to the singular performance of their stock markets from the intensification of the financial crisis in autumn of 2008. As is well known, these peripheral countries were severely punished by the international financial crisis and, especially, the Eurozone sovereign debt crisis from late 2009. As a result, the behavior of their equity markets during the period around the financial turmoil was mostly driven by the poor economic prospects and deteriorating macroeconomic fundamentals, while the development in interest rates played only a marginal role.

Finally, Figure 3 summarizes the key findings of the QQ approach, displaying the combinations of quantiles of 10-year Treasury bond yield changes and stock returns which produce the most intense interest rate-equity market link for each country. As one can see, the strongest relationship for the great majority of countries concentrates in the region which blends the lowest quantiles of 10-year government bond yield variations with the lowest quantiles of stock returns. This confirms that the peak of the interest rate-equity market association is generally reached in times of financial turmoil characterized by sharp declines in 10-year Treasury yields and extreme downturn in stock markets. Figure 4 also illustrates the singular behavior of the interest rate-equity market nexus exhibited by countries of the euro area’s periphery, possibly as a result of the significant influence of the Eurozone sovereign debt crisis on their stock and sovereign bond markets. In addition, it is worth noting that the main empirical results are maintained during the sub-period corresponding to the global financial crisis.³

Figure 3. Summary of results of the QQ approach by country



³ These results are available as supplementary material to this article.

Note: The graph shows the average combination of quantiles of changes in 10-year sovereign bond yields and quantiles of stock returns where the QQ approach detects the strongest interest rate-stock market link for each country during the entire sample period.

5. Conclusions

This study investigates the link between changes in 10-year Treasury bond yields and stock returns for fourteen advanced countries employing the QQ (quantile-on-quantile) methodology introduced by Sim and Zhou (2015). The QQ approach goes a step further than the standard quantile regression, capturing the dependence conditional not only on the stock market performance, but also on the interest rate environment.

Our empirical results reveal that the interest rate-equity market association has positive sign for most pairs of quantiles of both variables and exhibits a rather similar pattern for the majority of countries. However, a weaker and primarily negative relationship is found for some of the Eurozone peripheral countries most battered by the recent sovereign debt crisis, i.e. Greece, Ireland and Portugal. This result may be largely attributed to the greater influence of deteriorating macroeconomic fundamentals and poor future economic prospects on the stock markets of these peripheral countries over the past few years. Furthermore, the linkage between movements in 10-year government bond yields and stock returns varies greatly across quantiles of both variables within each country, demonstrating that the interest rate-equity market nexus is dependent on both the cycle of the stock market and the nature of interest rate shocks. The findings for the great majority of countries also show that the connection between 10-year interest rate variations and equity returns is stronger in times of extreme fluctuations in both stock and bond markets, and particularly in environments characterized by sharp declines in 10-year government bond yields and markedly bearish conditions in the stock market, such as those occurring during the worldwide financial crisis of 2008-2009 and the Eurozone debt crisis since late 2009. On the contrary, changes in 10-year Treasury bond yields have little impact on stock returns during non-extreme conditions in equity and sovereign bond markets. This evidence is in accordance with the commonly accepted view that the co-movement between financial markets increases substantially during periods of financial crisis and bear markets. To sum up, our results show the presence of a nonlinear and asymmetric relationship between yields on 10-year sovereign bonds and stock markets at the international level.

The evidence reported in this paper has obvious implications for various economic agents who will benefit from a comprehensive knowledge of the interest rate-equity market nexus. On the one hand, investors and portfolio managers must give close attention to the conditions in stock and sovereign bond markets as the optimal capital allocation, diversification and risk hedging strategies may vary drastically depending on the specific scenarios in both markets. For policy makers it is also crucial to accurately assess the interest rate-stock market connection under different market environments. In this way, they will be able to take the most adequate measures at any given time with the aim of limiting sharp simultaneous declines in sovereign bond and stock markets and, hence, preserving financial and macroeconomic stability.

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