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Impact of changes in the level, slope and curvature of interest rates on U.S. sector returns: an asymmetric nonlinear cointegration approach

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ABSTRACT

This article examines the sensitivity of U.S. sector equity indices to changes in nominal interest rates and in the corresponding principal components (level, slope and curvature of the U.S. yield curve) over the period 1990–2013 using factor models and a nonlinear autoregressive distributed lag (N.A.R.D.L.) approach. Furthermore, for robustness, this research analyses whether the sensitivity of sector stock returns is different depending on the stage of the economy, splitting the whole sample period into two sub-periods: pre-crisis and subprime crisis. In general, the empirical results confirm a substantial exposure to interest rate risk that depends on the model used and the period analysed. In addition, considering the three principal components of the U.S. yield curve, the sensitivity to changes in these components tends to be stronger during the subprime crisis sub-period. Finally, in the N.A.R.D.L. context, about 50% of sectors show long-run relations between sector stock returns and the explanatory factors, mainly during the whole sample and the pre-crisis sub-period. Nevertheless, short-run responses may be mostly shown in the subprime crisis sub-period. Therefore, our results evidence that nominal interest rates and its three components would have asymmetric effects on the U.S. stock returns at sector level, depending on the stage of the economy.

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Introduction

The analysis of the sensitivity of sector returns in the U.S. to changes in the market return and the nominal interest rates is a topic of great relevance at the international level, as more and more companies choose external funding to develop its activity (Bartram, 2002; Ferrer et al., 2005; Jammazi, Ferrer, Jareño, & Hammoudeh, 2017; Jareño, 2008; Jareño, Ferrer, & Miroslavova, 2016; Martínez, Ferrer, & Escribano, 2015; among others). The external financing of a company are the means with which it has to meet its payment commitments or to make productive investments for greater business growth sustained over time. However, the ideal business model is one that combines equitable distribution percentages of both internal and external financing. In this sense, the significance of the topic is increasing and has great relevance for the consulting sector of the company, since an increase in interest rates implies a higher cost of external financing. Thus, company managers can foresee the sensitivity of sector returns to changes in risk factors, offering economic, financial and fiscal advice for the company. Furthermore, it should be noted that in the last decades, investment in fixed income, besides being a source of stable income and moderation of portfolio volatility, has contributed a high profitability to the investors. The great cycle of interest rate reduction that has been developing since the beginning of the 1980s has translated into the fact that, in addition to the annual interest paid by the bonds, the investor has obtained an additional return from the revaluation of the same. In this period, fixed income has not only acted as a factor of portfolio stability during periods of stock market crashes, but also has outperformed most alternative assets including equities. In this sense, the process of capital transfer generated between the fixed income and equity markets in response to interest rate variations is a result of the strong competition between both markets in terms of attracting investments (Ferrer et al., 2005).

Thus, the aim of this research is to analyse the sensitivity of sector returns to changes in the U.S. market return and nominal interest rates, during the period between January 1990 and April 2013 in the U.S. In order to evaluate this impact, the models of Stone (1974) and Nelson and Siegel (1987) have been used, which take into account the mentioned risk factors (market return and the nominal interest rate) to estimate the sensitivity of sector returns to changes in them. The article also analyses the main components of the U.S. term structure of interest rates (T.S.I.R.). So, we can study the impact of changes in the level, slope and curvature of interest rates on sector portfolio returns (main components). According to the previous literature and the results of the study, there is a statistically significant and negative relationship between the unexpected changes in interest rates and the sector stock returns, showing that both the variations and the volatility of interest rates have a negative and statistically significant impact on the stock returns of financial institutions (Fraser, Madura, & Weigand, 2002; Sweeney & Warga, 1986).

This study focuses on the North American stock market, since the U.S. is one of the most powerful and influential countries in the rest of the world in economic terms. In this sense, the U.S. stock market is one of the main axes of economic reference in the world at the present time, reason why its sector returns are of vital importance for other economies. The U.S. economy has a high percentage of external

financing, both public and private, which makes it more relevant for our study. This fact implies that there is a greater interest rate risk for the U.S. economy, which subsequently has a greater or lesser impact on the rest of the countries worldwide.

In this context, we try to explain the behaviour of the U.S. sector portfolio returns in relation to different explanatory factors, such as the U.S. stock market index, proxied by the Standard &Poor (S&P) stock market index, and nominal interest rates, proxied by the 10-year government bond. Thus, the purpose of this article is to study the variations in sector returns to changes in the U.S. interest rates. In addition, this research places special emphasis on interest rate risk, which consists of analysing the variation experienced by the value of companies (both financial and non-financial) to unexpected variations in interest rates. In addition, the interest rate will be broken down into its main components: Level, Slope and Curvature. Moreover, the changes in U.S. sector returns will be analysed to changes in interest rates for the whole period (1990–2013), as well as two clearly differentiated sub-periods: (1) pre-subprime crisis sub-period (1990–2007); and (2) global financial crisis sub-period (2008–2013). Finally, the methodology applied in this paper is the Seemingly Unrelated Regression model (SUR), taking into account the presence of heteroscedasticity and contemporary correlation between error terms across equations. Moreover, to check the robustness of the results, a nonlinear A.R.D.L. cointegration approach (N.A.R.D.L.) as an asymmetric extension to the well-known A.R.D.L. model of Pesaran and Shin (1999) and Pesaran, Shin, and Smith (2001) is also applied to capture both long-run and short-run asymmetries in our variable of interest.

Thus, this article contributes to the existing literature in several ways. First, to the best of our knowledge, this study is the first that expands the investigation of the interest rate sensitivity of U.S. sector stocks using the nonlinear autoregressive distributed lag (N.A.R.D.L.) method and, simultaneously, captures the dynamics of the entire T.S.I.R. with three factors representing the level, slope and curvature of the yield curve. Second, for robustness, this paper studies whether the effect of changes in interest rates (and its three components) on U.S. sector stock returns changes under different stock market conditions, i.e., in bullish, bearish or relatively stable markets. To that end, the full sample period has been divided into two sub-periods: pre-crisis and global financial crisis. Thus, this study may assess whether the global financial crisis of 2007–2008 has significantly disturbed interest rate exposure of the U.S. stock market.

Finally, this research is organised as follows. First, Section 2 includes a literature review of the interest rate sensitivity. Section 3 specifies the empirical model, data and methodology used in this study. Section 4 shows the empirical findings of our factor asset pricing models and the N.A.R.D.L. model for the whole sample period. Section 5 presents the bearish and bullish states of the U.S. stock market, detailing the results of our factor models and the N.A.R.D.L. model for both pre-crisis and crisis sub-periods, and, finally, Section 6 comprises the main concluding remarks of this research.

Literature review

Different papers analyse the sensitivity of stock prices to interest rate and other macroeconomic variables in different periods and markets. Lynge and Zumwalt

(1980) test the interest rate sensitivity of commercial bank common stock returns for the 1969 through 1972 period and found that interest rate sensitivity depends on the term of interest rates, being different for short-term and long-term interest rates; additionally, they find that stock returns of banks were more sensitive than nonfinancial stock returns. In addition, they also found that the sensitivity of bank stock returns had changed over time.

Akella and Chen (1990) study the interest rate sensitivity of bank stock returns (1974–1984) under alternative econometric specifications. Results indicate that the sensitivity depends on the model specification and the period considered. Premawardhana (1997) analyse the interest rate sensitivity of stock returns in Sri Lanka for the period from January 1990 to December 1995 and found a negative relationship. These results are inconsistent with Geske and Roll (1983) that stock returns have a significant positive relationship with interest rates. Hasan, Samarakoon, and Hasan (2000) examine the ability of interest rates, as measured by Treasury bill rates of all three maturity periods, to track the expected returns in the Sri Lanka stock market during the 1990–1997 period. In contrast to the findings in most prior literature, the results of this study indicate that short-term interest rates in Sri Lanka are positively related to future returns.

Bulmash and Trivoli (1991) and Abdullah and Hayworth (1993) find a negative relationship between stock prices and the interest rates in the U.S. Madura and Schnusenberg (2000) examined the interest rate sensitivity of the bank stock returns and the U.S. Federal Reserve discount rate and found too they were negatively related.

Al-Qenae, Li, and Wearing (2002) made an important contribution by investigating the effect of interest rate on the stock prices during the period 1981–1997 in Kuwait showing that interest rate has negative and statistically significant effect on stock prices. Gan, Lee, Yong, and Jun (2006) also suggest that there exist a long-term negative relationship between stock prices and interest rate in New Zealand. On the contrary, Pilinkus and Boguslauskas (2009) analyse the short-run relationships in Lituania from the January of 2000 to the June of 2009 and conclude that short-term interest rates negatively influence on stock market prices. Alam and Uddin (2009) examined evidence supporting the existence of share market efficiency based on the monthly data between stock index and interest rate for 15 developed and developing countries and for all of the countries it is found that interest rate has significant negative relationship with share price.

More recently, Amarasinghe (2015) examines the causal relationship between stock price and interest rate, using monthly data for the period from January 2007 to December 2013 concluding that interest rate is a significant factor for stock price changes and shows significant negative relationship between variables. Stevenson (2015) examine the price impact of rate changes on both the general stock markets and on bank stocks in European countries over the period 1987–1998 concluding that not only do non-German banks and equities react to Bundesbank policy, but that the markets appear to differentiate with regard to the importance of rate changes, both in terms of the market concerned and financial institutions and equities in general.

In this context, the main contribution of this article is to expand the investigation of the U.S. stock market sensitivity to changes in interest rates (and its components) using the N.A.R.D.L. method. Moreover, for robustness, this article splits the full sample period into two different sub-periods: pre-crisis and global financial crisis.

Empirical model: Data and methodology

This section specifies the empirical model. In concrete, the first subsection shows the dataset and the sample used to analyse the sensitivity of companies' returns listed in the U.S. stock market index to changes in some explanatory factors. The second subsection details the methodology used in this article, comprising the Stone (1974) two-factor model, the Nelson and Siegel (1987) model, the principal component analysis (P.C.A.) and an asymmetric nonlinear cointegration approach (N.A.R.D.L.).

Data and sample period

The sample period analysed for the study of the sensitivity of U.S. sector returns is comprised between January 1990 and April 2013. Regarding the periodicity, monthly data have been used and their reference is the last day of quotation for each month. The sample has a total of 280 monthly observations, being the first observation in January 1990 and the last one in April 2013 (both inclusive). In addition, it is usual in financial literature to analyse the stock markets throughout a sample period such as 1990–2013 in order to contrast the differences between a period of economic growth (1990–2007) and a period of economic crisis (2008–2013) (e.g., Cremers & Pareek, 2016; Passari & Rey, 2015; among others). It is also a sufficiently broad and recent period to obtain consistent results. In addition, monthly frequency is preferred over daily frequencies for several reasons: for example, daily data are more contaminated by noise and anomalies such as day-of-the-week effects or non-synchronous trading bias than weekly observations (Arouri, 2012).

To perform the analysis of the U.S. sector returns, they have been taken into account as a dependent/explained (endogenous) variable and the U.S. stock market return and nominal interest rates as independent/explanatory (exogenous) variables. Furthermore, the latter has broken down into the level, slope and curvature of the T.S.I.R. or yield curve. Sectoral returns are estimated from the daily quotations extracted from the Thomson Reuters database within the period analysed, from January 1990 to April 2013. For the calculation of sector returns, natural logarithms have been used for the closing price of one month compared to the previous one. According to Ballester, Ferrer, and González (2011), the reason for conducting a sector analysis to estimate the effect of interest rate risk on stock market returns, instead of working with individual companies, is because it allows us to summarise a large amount of information about the behaviour of the stocks of all the companies in the sample. In addition, in this way the noise present in the data is minimised, mainly due to transitory shocks in the individual companies. Likewise, when performing our analysis by sectors, we can identify the differences between some sectors in terms of

sensitivity to changes in interest rates, as these may have important implications for business and investment decision-making.

The U.S. stock market return is proxied by data of the U.S. companies' stock prices included in the S&P 500 stock index, created by the financial services company Standard & Poor's. It includes the 500 companies with the highest contribution in the U.S. economy and it is weighted according to the market capitalisation of each of company.[1] The data of S&P500 index are extracted from the website https://es.finance.yahoo.com/. In addition, the stock market return has been obtained in the same way as sector stock returns, that is log returns: Ln (P_t/P_{t-1}). Finally, the interest rate is a very relevant explanatory factor, since its choice conditions the analysis (Jareño, 2006). Therefore, it has been decided to use the U.S. 10-year Treasury Bond as explanatory variable, since it has been used as a representative variable of the nominal interest rates of the North American market (Ferrando, Ferrer, & Jareño, 2017; González, Jareño, & Skinner, 2016; Sevillano & Jareño, 2018, among others). This 10-year nominal interest rate is used in most of the investigations when incorporating future expectations, so that the price of the securities is affected. Therefore, by using a long-term interest rate,[2] it is assured that these are more stable because their maturity is closer to the stocks's one, so that they are not influenced by monetary policy operations. This fact does not occur in short-term interest rates. The historical series of interest rates proxied by the 10-year Treasury bond returns for the sample period have been extracted from the database of the website http://www.treasury.gov/.[3]

Methodology

To analyse the variations in sector returns to changes in the market portfolio return and nominal interest rates, the estimation of two models is proposed: (1) Stone (1974) two-factor model; and (2) an extension of the Nelson and Siegel (1987) factor model. Both models are estimated for the total sample (between 1990 and 2013). Subsequently, to check the robustness of the results, the whole sample is broken into two sub-periods, in order to analyse whether the sensitivity of the sector returns is different depending on the phase of the economic cycle, that is, pre-subprime crisis sub-period (1990–2007) and subprime crisis sub-period (2008–2013).

First, we estimate the Stone (1974) two-factor model. The bulk of research starts from the extension of the simple market model through the addition of the unexpected change in the nominal interest rate as a further explanatory variable (Jareño, 2006; González et al., 2016, among others). Second, according to Akimov et al. (2015), many international Central Banks have a long tradition in estimating the T.S.I.R. using splines or parsimonious functional forms. Thus, the second model suggested is the Nelson and Siegel (1987), and applied by Czaja, Scholz, and Wilkens (2009, 2010), that decomposes the T.S.I.R. in its main components (Umar, Shahzad, Ferrer, & Jareño, 2018): Level (L), related to the long-end of the yield curve, is the first principal component; Slope (S), is the second principal component and can be seen as a short-term factor; and Curvature (C), is the third principal component and can be interpreted as the medium term factor. According to Díaz, Jareño, and Navarro (2010), Jareño and Tolentino (2012) and Wang and Wang (2015), among

others, the P.C.A. is applied to identify the three principal components of the U.S. yield curve.[4] Thus, the cumulative sum of the variance proportion, that is, the proportion of the variance explained for each principal component is 90.07% in the case of the first principal component (level), 99.39% in the case of the second principal component (slope), and 99.81% in the case of the third principal component (curvature). Therefore, the first three factors capture more than 99.8% of the variation in the U.S. yield curve.[5]

On the other hand, the relationship between stock returns and interest rates is usually studied using classical approaches such as O.L.S., and alternative methodologies, such as S.U.R., Q.R., cointegration, Granger causality, etc. While the techniques enable evaluation of their long-run relations as well as their short-run interactions, they presume symmetric relations between sector stock returns and changes in nominal interest rates (and its three components). Therefore, they are not adequate to capture potential asymmetries in the sector stock return dynamics. Thus, Shin, Yu, and Greenwood-Nimmo (2014) advance a nonlinear A.R.D.L. cointegration approach (N.A.R.D.L.) as an asymmetric extension to the well-known A.R.D.L. model of Pesaran and Shin (1999) and Pesaran et al. (2001), to capture both long-run and short-run asymmetries in a variable of interest. We adopt this modelling approach for our purpose. Thus, according to Arize, Malindretos, and Igwe (2017), a cointegrating nonlinear autoregressive distributed lag (N.A.R.D.L.) model of Shin et al. (2014) is applied to check for the possibility that the time series are nonlinearly cointegrated.[6] This methodology tests simultaneously the long- and short-run nonlinearities through the positive and negative partial sum decompositions of the regressors. It also offers the possibility of quantifying the respective responses to positive and negative shocks of the regressors from the asymmetric dynamic multipliers. The N.A.R.D.L. technique is an asymmetric extension to the well-known linear autoregressive distributed lag (A.R.D.L.) bounds testing technique of Pesaran, Shin, and Smith (2001).

Empirical findings

To analyse the variations in U.S. sector returns to changes in nominal interest rates, the Stone (1974) two-factor model as well as the factor model based on Nelson and Siegel (1987) are applied. Thus, these estimates may explain the sensitivity of U.S. sector returns to changes in the stock market return and nominal interest rate through a system of equations. The methodology used for the first estimates is the S.U.R. technique, which allows estimating the coefficients taking into account the presence of heteroscedasticity and contemporaneous correlation between the error terms.[7] For robustness and to capture both long-run and short-run asymmetries, an asymmetric nonlinear cointegration approach (N.A.R.D.L.) is applied.

Thus, this fourth section consists of two subsections. The first subsection shows the preliminary results of both Stone (1974) and Nelson and Siegel (1987) models for the whole sample period and the second subsection contains the results of the N.A.R.D.L. approach also in the full period.

Table 1. Analysis of the sector returns according to the Stone (1974) and the Nelson and Siegel (1987) model for the whole sample.

Sector/Variables	IR	L	S	C
Consumer Discretionary	0.891708*	0.1081	0.5062	−0.7470*
Consumer Staples	−1.996064***	−0.6076 **	−0.2602	0.0410
Energy	0.643387	0.3836	−1.0250*	−0.1630
Financials	−0.969487	−0.6316 *	0.0550	0.0893
Health Care	−1.969525***	−0.4187	−0.3835	0.7718
Industrials	0.54279	−0.0378	0.2008	−0.4505
Information Technology	2.327262**	1.0220 **	0.2160	0.1886
Materials	2.095555***	0.5292	0.0677	−0.6694
Telecommunications Services	−1.082078	−0.2496	0.1679	0.2064
Utilities	−3.32428***	−0.1889	−2.0043***	1.0214

Notes: This table reports the coefficient estimates of the Stone (1974) and the Nelson and Siegel (1987) model for each U.S. sector stock portfolio.
IR: changes in nominal interest rates, **L**: changes in the level of the yield curve, **S**: changes in the slope of the yield curve, **C**: changes in the curvature of the yield curve.
As usual, *, **, *** indicate statistical significance at the 10%, 5% and 1% levels, respectively.

Preliminary results: whole sample period

First, an analysis of the behaviour of sector returns to changes in the nominal interest rates is carried out for the whole sample period (1990–2013).

Stone (1974) two-factor model: whole sample period

Then, according to Table 1, all sectors show a statistically significant and positive sensitivity to changes in the stock market return. According to Jareño (2006) affirms, this estimate shows that any change in the stock market return means a change in the same direction in the returns of all the sectors analysed.

In contrast, there are differences in terms of the sensitivity shown by the sectors to unexpected changes in the nominal interest rate. This sensitivity is statistically significant and positive in the sectors 'Consumer Discretionary', 'Information Technology' and 'Materials'. So, any change that occurs in the nominal interest rate, means a change in the same direction in the sector returns described above. However, the sensitivity is statistically significant and negative in the sectors 'Consumer Staples', 'Health Care' and 'Utilities', since any change that occurs in the nominal interest rates means a change in the opposite direction in the returns of the sectors described above.

The explanatory power of the model comprising the full period of the sample is high, because the adjusted R^2 coefficient ranges between 24% (Utilities) and 82% (Industrials). So, in general, at least 24% – and up to 82% – approximately, the variations in sector returns would be explained by changes in the variables analysed and included in this model.

Nelson and Siegel (1987) model: whole sample period

Table 1 also shows that according to Nelson and Siegel (1987) model, all sectors show a statistically significant and positive sensitivity to changes in the stock market returns. These results are similar to those obtained from the Stone (1974) model. As with the model previously estimated, the analysis of the stock market return shows

that any change that occurs in it, means a change in the same direction in the sector returns studied in this article (Jareño, 2006; Umar et al., 2018).

As previously said, there are relevant differences in the sensitivity shown by the sectors to unexpected changes in the main components of the nominal interest rate. On the one hand, the sensitivity of sector returns to unexpected changes in the Level, Slope and Curvature of the T.S.I.R. is statistically significant and positive only in the sector "Information Technology" for the first principal component "Level", so unexpected changes in the Level imply changes in the same direction in the return of all the sectors. On the other hand, it is statistically significant and negative in the sectors "Consumer Staples" and "Financials" for the Level, "Energy" and "Utilities" for the Slope and "Consumer Discretionary" for the Curvature. Thus, any change in the principal components of the T.S.I.R.s implies changes in the opposite direction in the sector returns.

The extended version of the Nelson and Siegel model shows that the explanatory power in the whole sample period is high, since the adjusted R^2 coefficient ranges between 24% (Utilities) and 82% (Industrials). Therefore, between 24% and 82% of the variations in the sector returns are explained by changes in the stock market returns and the principal components of the T.S.I.R.s.

N.A.R.D.L. approach: whole sample period

This subsection shows results of the non-linear A.R.D.L. estimation and collects long-run and short-run relations between sector stock returns and nominal interest rates and its three principal components (level, slope and curvature) for the whole sample period and the cointegration and asymmetry tests. In the N.A.R.D.L. estimation, the maximum lag order considered is 4.[8] The bounds F-statistics show that all sectors co-move in the long-run, with the exception of Industrials, Energy, Materials and Telecommunication Services. Thus, we do not find long-run effects of increases or decreases in nominal interest rates in the case of these four sectors.

Specifically, Consumer Discretionary shows long-run relations between stock returns and changes in nominal interest rates and in its three principal components. Utilities exhibits long-run relations between sector stock returns and changes in nominal interest rates and in the slope of the yield curve. Additionally, Consumer Staples, Financials, Health Care and Information Technology only show long-run relations between sector stock returns and one of these explanatory factors (changes in nominal interest rates, changes in the curvature, changes in the level and, changes in the curvature of the yield curve, respectively, for each of those last four sectors).

The long-run coefficients of changes in nominal interest rates are positive and significant at 1% significance level for Consumer Discretionary, but negative and statistically significant at 10% for Consumer Staples and Utilities. These long-run coefficients of changes in the level of the U.S. yield curve are positive and significant at 1% significance level for Consumer Discretionary and Health Care. The long-run coefficients of changes in the slope of the yield curve are negative and significant at 1% significance level for Consumer Discretionary, but positive and statistically significant at 10% for Utilities. Finally, these coefficients of changes in the curvature of the

Table 2. Regression results of non-linear A.R.D.L. models: asymmetry and cointegration tests for the whole sample.

Sector	IR			L			S			C		
	LAsym	SAsym	Cointegr	LAsym	SAsym	Cointegr	LAsym	SAsym	Cointegr	LAsym	SAsym	Cointegr
Consumer Discretionary	2.758*	—	6.479***	2.106	—	6.677***	0.909	—	4.208***	0.750	—	3.410**
Consumer Staples	1.130	—	2.180*	0.607	—	1.932	0.307	—	1.399	0.327	—	1.408
Energy	0.637	—	0.856	0.500	—	0.633	0.400	—	1.500	0.112	—	0.518
Financials	0.635	0.278	1.591	0.942	6.184***	1.801	1.127	—	1.876	1.205	—	3.523**
Health Care	0.445	—	0.996	1.323	—	3.602***	0.301	—	0.434	1.118	—	1.841
Industrials	0.001	—	0.404	0.030	—	0.403	0.056	6.747***	0.500	0.094	—	0.392
Information Technology	0.002	4.874***	1.045	0.268	6.879***	0.717	0.052	—	1.593	1.585	—	2.833**
Materials	0.009	—	0.342	0.002	—	0.538	0.004	6.114***	0.341	0.001	—	0.147
Telecommunications Services	0.610	—	0.875	0.003	—	0.371	0.367	9.296****	0.632	0.592	0.291	1.088
Utilities	1.363	—	2.052*	0.613	—	0.932	0.203	7.324***	1.866*	0.093	0.514	0.745

Notes: This table reports the coefficient estimates of the N.A.R.D.L. model for each U.S. sector stock portfolio.
IR: changes in nominal interest rates, L: changes in the level of the yield curve, S: changes in the slope of the yield curve, C: changes in the curvature of the yield curve.
LAsym refers to the Wald test for the null of long-run symmetry defined by $-\beta_2/\beta_1 = -\beta_3/\beta_1$.
SAsym refers to the Wald test for the null of short-run symmetry defined by $\gamma_i^+ = \gamma_i^-$.
Cointegr refers to the Wald test for the presence of cointegration defined by $\beta_1 = \beta_2 = \beta_3 = 0$.
As usual, *, **, *** indicate statistical significance at the 10%, 5% and 1% levels, respectively.
The critical values are available in Narayan (2005), in case of small sample size.

U.S. yield curve are negative and significant at 5% significance level for Consumer Discretionary, but positive and statistically significant at 5% for Financials and Information Technology.

Regarding the long-run elasticities for i_{t-i}^{+} (the cumulative sum of positive changes in nominal interest rates) and i_{t-i}^{-} (the cumulative sum of negative changes in nominal interest rates), for instance, a 10% increase in nominal interest rates is related to the increase in the stock returns of Consumer Discretionary by about 8.85%. Furthermore, clearly, the sector stock returns response more to positive changes because the coefficient is larger. The long-run symmetry can be tested by means of a Wald test. Our results indicate a greater intensity of positive effects over negative ones. Furthermore, the null hypothesis of long-run symmetry is not rejected, with the exception of Consumer Discretionary for changes in nominal interest rates.

As regards the short-run dynamics, to test for symmetry in the short-run model, one can use the strong form, which implies $\gamma_i^{+} = \gamma_i^{-}$. The null hypothesis of short-run symmetry is rejected for Financials (to changes in the level factor), Information Technology (to changes in nominal interest rates and the level of the U.S. yield curve), and Industrials, Materials, Telecommunication Services and Utilities (to changes in the slope factor). Therefore, there is evidence of asymmetric short-run responses in more than 50% of the U.S. sector stock portfolios. Thus, this study may corroborate the symmetry in the relation between U.S. sector stock returns and nominal interest rates (and its three principal components). So nonlinear asymmetries are relevant to study the relationship between the U.S. stock market and nominal interest rates at sector level.

There may be a statistically significant effect of the cumulative sum of positive and negative changes in nominal interest rates (and its three components) and also the short-run influences of increases and decreases of nominal interest rates in all sectors, except for Industrials (to changes in nominal interest rates and changes in the level of the yield curve), Health Care (to changes in the slope of the U.S. yield curve) and, finally, Consumer Discretionary (to changes in the curvature of the yield curve). Moreover, the sign of each effect depends essentially on increases and decreases of the explanatory variables, lags and sectors. Although the effect of the cumulative sum of positive and negative changes in nominal interest rates is statistically significant for once-lagged cumulative sum, we also find a higher persistence in the effect of changes in nominal interest rates (and its three components) as reflected by statistically significant coefficients for, not only these contemporaneous variables, but also for 1-, 2-, 3- and 4-lags. The explanatory power of the N.A.R.D.L. model ranges from 21% (for Utilities to changes in the level of the yield curve) to more than 83% (for Industrials to changes in the slope of the U.S. yield curve).

Bearish and bullish states of the U.S. stock market

For robustness, this research analyses how sector returns vary to changes in nominal interest rates, taking into account the economic cycle. Therefore, estimates distinguish two sub-periods: pre-crisis and sub-prime crisis. In order to justify the breakdown of the whole sample period, we run the Chow breakpoint test in a N.A.R.D.L.

Table 3. Analysis of the sector returns according to the Stone (1974) and the Nelson and Siegel (1987) model for the pre-crisis sub-period.

Sector/Variables	IR	L	S	C
Consumer Discretionary	1.609111***	0.3720	0.5370	−0.70721*
Consumer Staples	−1.925654**	−0.6151*	−0.0315	−0.0116
Energy	−0.379562	−0.2096	−1.0439	−0.7823
Financials	−1.473233*	−0.3152	−0.7888	0.5471
Health Care	−2.283641**	−0.5586	−0.2170	0.5752
Industrials	0.805871	0.131865	−0.0040	−0.5518
Information Technology	3.055757**	1.1013**	0.5267	0.3182
Materials	2.012496**	0.3407	−0.0321	−1.2261*
Telecommunications Services	0.491515	−0.1549	1.406*	0.6109
Utilities	−3.945371***	−0.4971	− 1.7164**	1.1409

Notes: This table reports the coefficient estimates of the Stone (1974) and the Nelson and Siegel (1987) model for each U.S. sector stock portfolio.
IR: changes in nominal interest rates, **L**: changes in the level of the yield curve, **S**: changes in the slope of the yield curve, **C**: changes in the curvature of the yield curve.
As usual, *, **, *** indicate statistical significance at the 10%, 5% and 1% levels, respectively.

framework.[9] This test shows that all sectors (except for Consumer Staples, Health Care and Utilities) confirm that January 2008 is an appropriate date to split the whole sample period into two different sub-samples.

Thus, this section studies the effect that the economic crisis may have on the relationship between the sector stock returns and the explanatory variables included in both factor models proposed in this study: the Stone (1974) two-factor model and the Nelson and Siegel (1987) model. Therefore, for robustness, this study splits up the whole sample into two different sub-periods: pre subprime crisis sub-period (January 1990–December 2007) and subprime crisis sub-period (January 2008–April 2013). The division into these two consecutive sub-periods is determined by the subprime financial crisis unleashed by the fall of Lehman Brothers in September 2008 (Ferrando et al., 2017). Moreover, this division has been corroborated by the Chow breakpoint test in a N.A.R.D.L. framework and for nominal interest rates and its three principal components (level, slope and curvature of the yield curve).

Thus, the structure of this fifth section is the following one: The first subsection shows preliminary results of both Stone (1974) and Nelson and Siegel (1987) models for pre-crisis and crisis sub-periods and, on the other hand, the second subsection contains the results of the N.A.R.D.L. approach for the pre-crisis and the crisis sub-periods.

Preliminary results: pre-crisis and crisis sub-periods

The Stone (1974) two-factor and the Nelson and Siegel (1987) model: pre-crisis Sub-period: January 2000–December 2007

This subsection studies the Stone (1974) two-factor model in the period before the beginning of the subprime crisis, characterised by some economic stability. Table 3 shows that all the sectors exhibit a positive and statistically significant sensitivity to changes in the stock market return, that is, changes in this explanatory variable involve changes in the same direction in the returns of the U.S. sectors.

The sensitivity of sector returns to unexpected changes in nominal interest rates is positive and statistically significant in the sectors 'Consumer Discretionary',

'Information Technology' and 'Materials', so any change that occurs in the nominal interest rate implies changes in the same direction in the sector returns. In this sense, no differences are observed with respect to the full period according to the Stone (1974) model. Thus, as in the whole period, this sensitivity is negative and statistically significant in the sectors 'Consumer Staples', 'Financials', 'Health Care' and 'Utilities', so any change that occurs in the interest rate means a change in the opposite direction in the returns of the sectors described above. It is important to note that the sector 'Financials' presents a statistically significant coefficient in the analysis prior to the subprime crisis, although not when analysing the entire period. Finally, the explanatory power of the model considering the pre-crisis period of the sample is high, because the adjusted R^2 coefficient ranges between 19% (Utilities) and 77% (Industrials). In general, the explanatory power is still high, although it has been minimally reduced compared to the full sample period.

Table 3 also shows the estimates of the Nelson and Siegel model during the pre-crisis sub-period. It remarks that all sectors show a positive and statistically significant sensitivity to changes in the stock market return. As with the model previously analysed, the study of the stock market return shows that changes in this explanatory factor involve changes in the same direction in all the sector returns. On the other hand, with regard to the sensitivity to unexpected changes in the main components of the T.S.I.R., there are relevant differences among sectors.

Thus, the sensitivity of sector returns to unexpected changes in the main components (Level, Slope and Curvature) of the T.S.I.R.s is statistically significant and positive in the sector 'Information Technology' for the first principal component (Level) and 'Telecommunications' for the second principal component (Slope). As seen in previous analyses, any change in the principal component 'Level' and 'Slope' involves a change in the same direction in the sector returns. However, the sensitivity of sectorial returns to unexpected changes in the principal components of the nominal interest rates is statistically significant and negative in the sector 'Consumer Staples' for the first principal component (Level), in 'Utilities' for the second principal component (Slope), and in 'Consumer Discretionary' and 'Materials' for the third principal component (Curvature). Therefore, changes in these principal components imply changes in the opposite direction in the sector returns. It should be noted that before the crisis some sectors show statistically significant sensitivity that are not in the full period, as is the case of 'Telecommunications'. It is also important to note that the sector 'Financials' does not show statistically significant sensitivity in the period prior to the subprime crisis, but it does when the full period is analysed. Finally, the explanatory power of the Nelson and Siegel (1987) model in the pre-crisis period is high is high, because the adjusted R^2 coefficient oscillates between 18% (Utilities) and 77% (Industrials and Consumer Discretionary), showing similar values that in previous analyses.

The Stone (1974) two-factor and the Nelson and Siegel (1987) model: crisis Sub-period: January 2008–April 2013

Table 4 analyses the sector returns according to the Stone (1974) model for the subprime crisis sub-period and indicates that all sectors show a statistically significant

Table 4. Analysis of the sector returns according to the Stone (1974) and the Nelson and Siegel (1987) model for the crisis sub-period.

Sector/Variables	IR	L	S	C
Consumer Discretionary	−1.375324	−1.0241**	0.3458	−0.7581
Consumer Staples	−2.249246***	−0.6829*	−0.9700*	−0.1608
Energy	2.199616	1.9447**	0.1214	4.4133*
Financials	−1.339208	−3.1467***	1.9931*	−5.1692**
Health Care	−1.004966	0.2028	−0.5664	2.5739
Industrials	−1.447287	−1.4908***	1.1401**	0.3288
Information Technology	2.796333**	2.4229***	−0.8884	1.5623
Materials	0.946632	0.5307	1.5266*	4.6832***
Telecommunications Services	−4.411052**	−0.2918	−5.0918***	−7.5279***
Utilities	−2.117788	0.5943	−3.5357***	−3.2847*

Notes: This table reports the coefficient estimates of the Stone (1974) and the Nelson and Siegel (1987) model for each US sector stock portfolio.
IR: changes in nominal interest rates, L: changes in the level of the yield curve, S: changes in the slope of the yield curve, C: changes in the curvature of the yield curve.
As usual, *, **, *** indicate statistical significance at the 10%, 5% and 1% levels, respectively.

and positive sensitivity to changes in the stock market return as in all previous analyses, that is, any change in the stock market return means a change in the same sense in the performance of all the American sectors.

It can also be observed that the sensitivity of sector returns to unexpected changes in nominal interest rates is positive and statistically significant only in the sector 'Information Technology', so any change in nominal interest rates involves a change in the same direction in the sector returns. Nevertheless, this sensitivity is negative and statistically significant in the sectors 'Consumer Staples', and 'Telecommunications', which produces an opposite effect, since any change that occurs in the interest rate, means a change in the opposite direction in the performance of the sectors described above. The explanatory power of the Stone model along the period 2008 to 2013 is high, since the adjusted R^2 coefficient ranges between 43% (Utilities and Telecommunications Services) and 92% (Industrials).

Table 4 also shows that all sectors exhibit a positive and statistically significant sensitivity to changes in the stock market return according to the Nelson and Siegel model during the pre-crisis sub-period. As with the model previously studied, the analysis of this explanatory factor shows that any change in it involves a change in the same direction in the sector return. On the other hand, there are relevant differences in terms of the sensitivity of the sectors to unexpected changes in the three principal components of the T.S.I.R.s.

The mentioned sensitivity of sector returns to unexpected changes in the three principal components (Level, Slope and Curvature) of the nominal interest rates is positive and statistically significant in the sector 'Energy' and 'Information Technology' for the first principal component (Level), in sectors 'Financials', 'Industrials' and 'Materials' for the second principal component (Slope) and in 'Energy' and also 'Materials' for the third principal component (Curvature). Thus, changes in the three principal components imply changes in the same direction in the performance of the sectors studied in this research. However, this sensitivity of sector returns to unexpected changes in the principal components is negative and statistically significant in the sector 'Consumer Discretionary', 'Consumer Staples', 'Financials' and 'Industrials' for the first principal component, 'Consumer Staples'

'Telecommunications' and 'Utilities' for the slope and 'Financials', 'Telecommunications' and 'Utilities' for Curvature. Thus, any change in the level, slope and curvature of the T.S.I.R.s means a change in the opposite direction in sector returns. Lastly, the explanatory power of the model that includes the period of the sample is high, since the adjusted R^2 coefficient ranges between 51% (Utilities) and 90% (Industrials). Therefore, it is similar to the analyses carried out previously, providing estimates more reliable than with the previous model.

N.A.R.D.L. approach: pre-crisis and crisis sub-periods

N.A.R.D.L. approach: pre-crisis sub-period: January 2000–December 2007

This subsection collects long- and short-run relations between sector stock returns and nominal interest rates and its three principal components (level, slope and curvature) during the pre-crisis sub-period (from January 2000 to December 2007) using the non-linear A.R.D.L. estimation. Table 5 confirm that half of the sectors co-move in the long-run. In concrete, Consumer Discretionary and Energy co-move to changes in nominal interest rates and its three principal components. Consumer Staples shows long-run relations between sector stock returns and changes in nominal interest rates, and the level and slope of the U.S. yield curve. Health Care co-moves to changes in nominal interest rates and the level of the yield curve and, finally, Information Technology exhibits long-run relations between its stock returns and changes in the slope of the yield curve.

The long-run coefficients of changes in nominal interest rates and the level of the yield curve are positive and statistically significant except for Consumer Staples, as previously shown in the whole sample. The long-run coefficients of changes in the slope of the yield curve are negative and statistically significant for Consumer Discretionary and Energy, but positive and statistically significant for Consumer Staples and Information Technology. Finally, the coefficients of changes in the curvature of the U.S. yield curve are positive and statistically significant for Consumer Discretionary and Energy.

On one hand, regarding the null hypothesis of long-run symmetry, it is only rejected during the pre-crisis sub-period for Consumer Discretionary and to changes in nominal interest rates. On the other hand, short-run symmetry is rejected for Consumer Discretionary (to changes in nominal interest rates), Information Technology (to changes in the level of the U.S. yield curve), and, finally, Telecommunication Services (to changes in nominal interest rates and the slope factor). These results are quite similar to those found for the whole sample.

Statistically significant impact of the cumulative sum of positive and negative changes in nominal interest rates (and its three components) and also the short-run influences of increases and decreases of nominal interest rates on all sectors is found for most of sectors, except for Industrials (to changes in nominal interest rates and changes in the level of the yield curve), Energy (to changes in the level of the yield curve), Health Care (to changes in the slope of the U.S. yield curve) and, finally, Consumer Discretionary and Materials (to changes in the curvature of the yield curve). As said for the whole sample, the sign of each impact depends essentially on

Table 5. Regression results of non-linear A.R.D.L. models: asymmetry and cointegration tests for the pre-crisis sub-period.

Sector	IR			L			S			C		
	LAsym	SAsym	Cointegr	LAsym	SAsym	Cointegr	LAsym	SAsym	Cointegr	LAsym	SAsym	Cointegr
Consumer Discretionary	3.246*	4.268**	5.795***	2.053	—	5.467***	0.168	—	4.754***	0.950	—	4.511***
Consumer Staples	1.232	—	3.159**	0.128	—	2.347*	1.260	—	2.215*	0.737	—	1.618
Energy	1.293	—	2.215*	1.465	—	2.212*	1.124	—	2.234*	1.491	—	3.300**
Financials	0.178	—	0.323	0.158	—	0.496	0.089	0.262	0.712	0.147	—	1.620
Health Care	0.821	—	2.500*	0.871	—	5.401***	0.850	—	0.935	1.066	—	1.796
Industrials	0.002	—	0.861	0.170	—	0.809	0.656	0.433	0.996	0.560	—	0.927
Information Technology	0.012	—	0.965	0.105	3.955**	0.720	1.257	—	2.367*	0.733	—	0.981
Materials	0.031	—	0.819	0.040	—	1.285	0.243	—	0.735	0.170	—	0.924
Telecommunications Services	0.148	4.600**	0.704	0.001	—	0.093	0.059	7.186***	0.351	0.097	0.253	1.228
Utilities	0.506	0.074	1.214	0.355	—	0.680	0.095	0.032	1.716	0.461	1.012	0.952

Notes: This table reports the coefficient estimates of the N.A.R.D.L. model for each U.S. sector stock portfolio.
IR: changes in nominal interest rates, L: changes in the level of the yield curve, S: changes in the slope of the yield curve, C: changes in the curvature of the yield curve.
LAsym refers to the Wald test for the null of long-run symmetry defined by $-\beta_2/\beta_1 = -\beta_3/\beta_1$.
SAsym refers to the Wald test for the null of short-run symmetry defined by $\gamma_i^+ = \gamma_i^-$.
Cointegr refers to the Wald test for the presence of cointegration defined by $\beta_1 = \beta_2 = \beta_3 = 0$.
As usual, *, **, *** indicate statistical significance at the 10%, 5% and 1% levels, respectively.
The critical values are available in Narayan (2005), in case of small sample size.

increases and decreases of the explanatory variables, lags and sectors. Again, we find a relevant impact of the cumulative sum of positive and negative changes in nominal interest rates for once-lagged cumulative sum. However, we also show a high persistence in the effect of changes in nominal interest rates (and its three components) as reflected by statistically significant coefficients for, not only these contemporaneous variables, but also for 1-, 2-, 3- and 4-lags. Finally, the explanatory power of the N.A.R.D.L. model ranges from about 16% (for Utilities) to more than 78% (for Consumer Discretionary), both to changes in the level of the yield curve.

N.A.R.D.L. approach: crisis sub-period: January 2008–April 2013

Lastly, Table 6 exhibits long- and short-run relations between sector stock returns and nominal interest rates and the three components of the U.S. yield curve (level, slope and curvature) during the subprime crisis sub-period (from January 2008 onwards) using the N.A.R.D.L. estimation.

First, only three sectors show long-run relations between sector stock returns and changes in nominal interest rates and its three components. Particularly, Telecommunications Services co-moves to changes in nominal interest rates and the level and curvature of the U.S. yield curve. Furthermore, Energy and Utilities exhibit long-run relations between their stock returns and changes in the level of the yield curve. Second, the long-run coefficients of changes in nominal interest rates and the level and curvature of the yield curve are generally positive and statistically significant. The long-run coefficients of changes in the level of the yield curve are positive and statistically significant for Energy, but negative and statistically significant for Utilities.

Concerning the null hypothesis of long-run symmetry, no sector rejects it during the subprime crisis sub-period to changes in nominal interest rates and its three components. Nevertheless, short-run symmetry is rejected for Consumer Discretionary (to changes in the three components of the yield curve), Consumer Staples (to changes in the slope and curvature of the U.S. yield curve), Energy (to changes in nominal interest rates and the level factor) and, finally, Financials (to changes in the level of the yield curve). These results are substantially different to those found for the whole sample.

In all cases, we find statistically significant impact of the cumulative sum of positive and negative changes in nominal interest rates (and its three components) and also the short-run influences of increases and decreases of nominal interest rates on all sectors. The only exception is Telecommunications Services (to changes in the level of the yield curve) and Materials (to changes in the slope of the U.S. yield curve). Thus, there are more statistically significant explanatory variables in the analysis of this sub-period. As previously said, we find a relevant impact of the cumulative sum of positive and negative changes in nominal interest rates for once-lagged cumulative sum. However, we also show a high persistence in the effect of changes in nominal interest rates (and its three components) as reflected by statistically significant coefficients for, not only these contemporaneous variables, but also for 1-, 2-, 3- and 4-lags. Finally, the explanatory power of the N.A.R.D.L. model in the crisis sub-period ranges from about 19% (for Utilities to changes in nominal interest rates) to

Table 6. Regression results of non-linear A.R.D.L. models: asymmetry and cointegration tests for the crisis sub-period.

Sector	IR			L			S			C		
	LAsym	SAsym	Cointegr	LAsym	SAsym	Cointegr	LAsym	SAsym	Cointegr	LAsym	SAsym	Cointegr
Consumer Discretionary	0.084	–	0.182	0.008	3.101**	1.043	0.134	7.972***	0.321	0.053	6.267***	0.419
Consumer Staples	0.254	–	0.294	0.358	–	0.579	0.017	4.309**	0.380	1.051	4.474**	1.167
Energy	0.329	4.370**	0.681	0.789	9.662***	3.031**	0.003	–	0.130	0.037	1.296	0.498
Financials	0.027	0.072	0.194	0.045	5.992***	0.217	0.431	–	0.747	0.095	0.211	0.668
Health Care	1.311	–	1.417	0.090	–	1.403	0.530	–	1.009	0.098	2.005	0.202
Industrials	0.002	–	0.993	0.029	–	1.224	0.365	–	1.109	0.229	–	1.071
Information Technology	0.097	–	1.057	0.169	–	1.187	0.049	–	0.929	0.016	0.760	1.345
Materials	0.090	0.360	1.005	0.004	1.482	0.705	0.047	–	1.116	0.396	–	1.667
Telecommunications Services	2.440	–	4.354***	1.319	–	4.852***	2.321	–	1.989	0.671	11.325***	2.563*
Utilities	0.506	10.161***	1.214	0.176	2.518**	2.611*	0.001	–	0.852	0.002	–	1.022

Notes: This table reports the coefficient estimates of the N.A.R.D.L. model for each U.S. sector stock portfolio.
IR: changes in nominal interest rates, L: changes in the level of the yield curve, S: changes in the slope of the yield curve, C: changes in the curvature of the yield curve.
LAsym refers to the Wald test for the null of long-run symmetry defined by $-\beta_2/\beta_1 = -\beta_3/\beta_1$.
SAsym refers to the Wald test for the null of short-run symmetry defined by $\gamma_i^+ = \gamma_i^-$.
Cointegr refers to the Wald test for the presence of cointegration defined by $\beta_1 = \beta_2 = \beta_3 = 0$.
As usual, *, **, *** indicate statistical significance at the 10%, 5% and 1% levels, respectively.
The critical values are available in Narayan (2005), in case of small sample size.

more than 92% (for Industrials to changes in the slope and the curvature of the yield curve).

Conclusion

This research focuses on analysing the sensitivity of U.S. sector returns at sector level to unexpected changes in the 10-year nominal interest rate. Thus, this article would contribute to the literature examining, in addition, the main components of the T.S.I.R.s (Level, Slope and Curvature) for the period from 1990 to 2013, in not only a framework of classical factor models (Nelson & Siegel, 1987; Stone, 1974), but also applying an asymmetric nonlinear cointegration approach (N.A.R.D.L.). Furthermore, for robustness, this research studies whether this sensitivity may vary under different market conditions, focusing on the subprime global financial crisis. So, the whole sample period is divided into two sub-periods: pre-crisis and subprime crisis. One of the main results of the factor models is the existence of a statistically significant relationship between sector returns and changes in the stock market return and nominal interest rates, both for financial and non-financial companies. In particular, based on the results about the sensitivity of U.S. sector returns to changes in the stock market return, the estimated coefficients are always positive and statistically significant at 99% for all sectors, regardless of the model used and the period analysed (the whole sample period and sub-samples of pre-crisis and crisis).

Another conclusive aspect is the difference between the sensitivity of certain sectors to changes in the nominal interest rate, depending on the factor model used and the period of the analysis. Thus, according to the Stone (1974) model for the whole period, sectors that show a greater positive sensitivity to the nominal interest rate are (S1) Consumer Discretionary, (S7) Information Technology and (S8) Materials. In contrast, the most statistically significant and negative sensitivity is found in sectors such as (S2) Consumer Staples, (S5) Health Care and (S10) Utilities. Moreover, the sectors that present a greater positive sensitivity for the three periods studied are (S2) Consumer Staples and (S7) Information Technology. The sensitivity of the sectors (S1) Consumer Discretionary, (S5) Health Care, (S8) Materials and (S10) Utilities is statistically significant in the pre-crisis sub-period, but not in the subprime crisis sub-period. In addition, the sector (S4) Financials shows a greater sensitivity in the pre-crisis stage, while the sector (S9) Telecommunications is more sensitive in the period of crisis. Regarding the Nelson and Siegel (1987) model, for the whole sample period, the only sector with positive and statistically significant sensitivity is (S7) Information Technology. However, the sectors that have a negative and statistically significant sensitivity are (S1) Consumer Discretionary, (S2) Consumer Staples, (S3) Energy, (S4) Financials and (S10) Utilities. The sectors that present a greater sensitivity for the three periods studied are (S1) Consumer Discretionary, (S2) Consumer Staples, (S7) Information Technology and (S10) Utilities. Thus, considering all the results obtained from the three samples and the two models used, the sectors Consumer Staples (S2) and Information Technology (S7) are the most sensitive to unexpected changes in 10-year interest rates, regardless of the sample chosen. These two models are reliable, since both have a very high explanatory power, for all the analysed periods,

fluctuating the percentages of the adjusted R^2 coefficient between 25% and 90% approximately. In short, the sensitivity shown by the different sector returns to unexpected changes in the 10-year nominal interest rates may be affected by the onset of the subprime crisis, hence the differentiated study in stages of this sensitivity.

Moreover, for robustness, the new asymmetric nonlinear cointegration approach (N.A.R.D.L.) has been applied in this study in order to avoid that the results are conditional upon assumptions regarding the data-generating process and the econometric method employed. Thus, about 50% of sectors show long-run elasticities between sector stock returns and, at least, one of the following explanatory factors: changes in nominal interest rates and changes in the level, slope and curvature of the U.S. yield curve. Nevertheless, we observe a more intense relation in the whole sample and the pre-crisis sub-period. Regarding short-run responses of the U.S. sector stock returns to the cumulative sum of positive and negative changes in nominal interest rates and its three components and to increases or decreases of nominal interest rates, we find a high persistence in this effect, mainly in the subprime global financial crisis sub-period. Therefore, the explanatory power of this N.A.R.D.L. estimate is higher than in previous periods, reaching up to 92% of explanatory power. In this context, our results may evidence that nominal interest rates and its three components would have asymmetric effects on the U.S. stock returns at sector level. In addition, this sensitivity depends upon the stage of the economy. To conclude, regarding the most important implications derived from this research, it should be noted that the results obtained allow us to determine which U.S. sectors are more sensitive to changes in interest rates, as well as to variations in their components: Level, Slope and Curvature. This is a relevant aspect both for investors and for managers and consultants of companies.

Notes

1. This index includes since the year 1957 the 500 largest U.S. companies, so it represents more reliably the real stock market situation than other indices such as the Dow Jones and the Nasdad100.
2. Traditionally, it is assumed that long-term interest rates have a greater influence on the evolution of economic activity and on investment decisions and/or business financing, which leads to a significant influence on the profitability of companies and, consequently, on their stock returns. (Ferrer et al., 2005).
3. The descriptive statistics of the variables are available upon request. The classical unit root tests of Augmented Dickey-Fuller (A.D.F.), and Phillips-Perron (P.P.), and the stationarity test of Kwiatkowsky, Phillips, Schmidt and Shin (K.P.S.S.) would verify the stationarity of the sector portfolio returns, the U.S. stock market, and the unexpected changes in nominal interest rates. These tests are also available on request.
4. This approach reduces dimensionality of the dataset by clustering them. Furthermore, P.C.s are linear combinations of original variables. Finally, the interpretation of the factors is not given *a priori*, but may be deducted after observing the relation of the factors with the initial variables (Wang & Wang, 2015).
5. The classical tests of unit root Augmented Dickey-Fuller (A.D.F.) and Phillips-Perron (P.P.) and the stationarity test Kwiatkowsky, Phillips, Schmidt and Shin (K.P.S.S.) verify that unexpected changes in the three principal components of the nominal interest rates have the same mean and variance over the period studied. The descriptive statistics and tests are available upon request.

6. Arize et al. (2017) remark some advantages of the N.A.R.D.L. model, such as it exhibits good small sample properties and is appropriate regardless of the stationary properties of the variables; it yields both estimates of short- and long-run coefficients, the model is free of residual correlation, so model is not prone to omitted lag bias.
7. Jareño (2006, 2008), Jareño and Navarro, (2010), Campos, Jareño, and Tolentino (2016), González et al. (2016) and Cano, Jareño, and Tolentino (2016), among others, estimate models separately using the 'seemingly unrelated regression' SUR technique (Zellner, 1962) for each of the sector samples, thereby taking into account possible contemporaneous correlation in the error terms across sectors as well as heteroskedasticity. It allows to avoid the distortions in the estimates from the presence of heteroscedasticity and simultaneous correlation between the error terms.
8. The extended estimation results are available upon request. Table 2 does only show asymmetry and cointegration test results.
9. The Chow breakpoint test results are available upon request.

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