



INTEREST RATE RISK ANALYSIS WITH MULTIFACTOR MODEL: THE US CASE

Natalia CAMPOS¹
Francisco JAREÑO²
Marta TOLENTINO³

Abstract

This study focuses on analyzing the influence of changes in 10-year nominal interest rates on US sector returns, distinguishing two different periods, before and after the subprime crisis. We run the three-factor model of Fama and French, which incorporates as explanatory factors the nominal interest rate and the size and growth opportunities factors. The US sensitivity varies across sectors and periods, but we evidence a similar response to the previous literature. Finally, the “size” effect is higher than the “growth” impact.

Keywords: interest rate sensitivity; sectoral analysis; US stock market; size factor; growth factor

JEL Classification: E31, G12, G3, L2

Acknowledgments

This work was supported by the “Ramón Areces Foundation public call to bid, 2013”, under Grant titled *Interest and inflation risk: study of the American stock market*.

I. Introduction

This study analyzes a very relevant topic for managers, whose crucial aim is to control the risk of stock portfolios, for which they need a measure of stock sensitivity to the changes in interest rates.

Specifically, this research contributes to give an explanation for the strong relationship between the US sector returns and some explanatory factors, such as the Standard &

¹ Department of Economic Analysis and Finance, Universidad de Castilla-La Mancha, School of Economic and Business Sciences. E-mail: nataliacgom29@gmail.com.

² Department of Economic Analysis and Finance, Universidad de Castilla-La Mancha, School of Economic and Business Sciences. E-mail: Francisco.Jareno@uclm.es. Corresponding author.

³ Department of Economic Analysis and Finance, Universidad de Castilla-La Mancha, School of Law and Social Sciences. E-mail: Marta.Tolentino@uclm.es.

Poor's 500 (S&P500) market index and nominal interest rates proxied by 10-year government bonds. Moreover, this paper includes the size and growth opportunities for companies.

According to previous literature, the changes in interest rates have a significant negative impact on stock returns of financial institutions (O'Neal, 1998 Hevert *et al.*, 1998, Staikouras, 2005, Au Yong and Faff, 2008, and Jareño, 2008). In addition, there is a direct relationship between the size of companies and their sensitivity to changes in interest rates (Bartram, 2002).

The analysis of the US stock market is justified because it is the leading world economy, with a direct impact on the international scene. Thus, the evolution of the S&P500 index (see Figure 1) shows that the economic situation changed substantially since the end of 2007 with the outbreak of the subprime crisis. Therefore, this research does not only analyze the whole sample period (1990-2013), but also two subsamples: the pre-crisis (1990-2007) and the subprime crisis period (2008-2013).

The rest of the study is organized as follows. Section two reviews the literature. The third section evaluates the data used and the presented methodology. Subsequently, in Section four, the analysis and interpretation of results are shown. Finally, Section five contains the main findings of this research, as well as possible future research leads.

II. Literature Review

The concept of financial duration allows for the analysis of the impact of changes in nominal interest rates on stock prices, as according to Jareño (2008 and 2010). The stock duration is defined as the sensitivity - with negative sign - of the stock price congruent to the changes in the discount rate. Based on this concept, this research includes other two explanatory factors of sectoral returns: the size of the firm (*size*) and growth opportunities (*growth*), proposed by Fama and French (1993), and applied by Hevert *et al.* (1998), Jareño (2008) and Ferrando *et al.* (2015).

The bulk of the previous research focuses on the financial sector. However, the interest rate risk can also exert a significant influence on the non-financial companies, primarily through the effect of interest rates on corporate borrowing costs and the value of financial assets and liabilities held by these companies (Bartram, 2002, and Jareño *et al.*, 2016).

For the non-financial sectors, some companies show a negative relationship between interest rates and sector returns. This negative sensitivity may be due to the low absorption capability of the movements in nominal interest rates caused by the changes in inflation rate. Companies in traditionally regulated sectors usually show this low capability, according to Jareño and Navarro (2010). There are also companies with a positive sensitivity to the changes in interest rates. This result can be due to a high inflation absorption ability of the involved companies.

Some authors refuse that asymmetry exists in reference to the sensitivity to changes in interest rates (Lim *et al.*, 2012). According to authors such as Ballester *et al.* (2009), there is a positive relationship between the bank size and the degree of exposure to interest rate risk. Furthermore, leverage is directly related to sensitivity, while growth opportunities and firm size are inversely related.

III. Data and Methodology

Our sample covers the period from the first week of January 1990 to the second week of April 2013. This analysis considers weekly sector returns as a dependent variable, including the US stock market return and nominal interest rates as explanatory variables and controlling for the size and growth opportunities of the company (Fama and French, 1993).

III.1. Variables

We use sectoral logarithmic returns obtained through daily prices from the Thomson Reuters database. The sectoral classification used is shown in Table 1. The market performance is proxied by the market index (S&P500), which includes 500 leading companies in the US Economy. S&P500 prices are obtained from the website of the Federal Reserve Bank of Saint Louis. Finally, we also obtain logarithmic returns.

We use the 10-year nominal interest rates as explanatory variable, since this term incorporates future expectations, and affects the price of securities (Jareño, 2008, and Ferrando *et al.*, 2015). This data is obtained from the official website of the US Treasury.

According to Fama and French (1993), the expected return from a market portfolio in excess of this type of risk-free rate is explained, *inter alia*, by (1) the difference between the stock portfolio returns of "small" companies (in terms of size) and "large" companies. This spread is well-known as the SMB (Small Minus Big) factor and refers to the explanatory variable of "firm size", and by (2) the difference between the stock portfolio returns with high book to market (B/M) equity and low B/M equity, called the HML (High Minus Low) factor. This variable refers to the "business growth opportunities". Both factors are obtained from the website of Kenneth R. French: http://mba.tuck.dartmouth.edu/pages/faculty/ken.french/data_library.html.⁴

III.2. The Fama and French Three-factor Model

This research applies the well-known three-factor model of Fama and French (1993) in order to analyze the sensitivity of sectoral returns to the changes in interest rates, controlling for the "size" and "growth" factors.

$$RS_{jt} = \alpha_j + \beta_j \cdot RCM_t + \mu_j \cdot \Delta TIN_t + \psi_j \cdot SMB_t + \phi_j \cdot HML_t + \varepsilon_{jt} \quad (1)$$

where: RS_{jt} is the weekly return of sector j , α_j is the independent term, β_j shows the market sensitivity of sector j , RCM_t is the weekly market return, μ_j shows the sensitivity of sector j to changes in nominal interest rates, ΔTIN_t is the non-expected change in the nominal interest rate, ψ_j shows the sensitivity of the sector j to changes in the "size" factor, SMB_t shows the weekly "size" factor return, ϕ_j shows the sensitivity of the sector j to changes in the "growth" factor, HML_t is the weekly "growth" factor return and, finally, ε_{jt} is a random disturbance.

⁴ The standard stationarity and unit root tests verify the stationarity of the variables, but we have to apply first differences in the case of nominal interest rates. The test results are omitted to lighten the article, but are available for those who wish to consult them.

Concretely, this paper applies an augmented Fama-French three-factor model, because it adds an interest rate change factor to measure the sectoral interest rate sensitivity (Jareño, 2008, and Ferrando *et al.*, 2015). Thus, this model confirms that not only the market risk but also other important factors associated to the characteristics of the firms allow for better explaining the evolution of sectoral stock returns. These factors are the size (market value, SMB) and book-to-market ratio (the book value divided by the market value of stocks, HML) of a firm. Moreover, some authors (such as Petkova, 2006, and Jareño, 2008, among others) confirm that the SMB and HML factors are good for predicting macroeconomic variables, specifically economy expectations and default risk premium.

Although the Fama-French model has been usually estimated by using the OLS regression method, this research estimates equation (1) by using the Seemingly Unrelated Regression (SUR) technique, taking into account the presence of heteroskedasticity and contemporaneous correlation between the error terms (Jareño, 2008).

IV. Main Results

The main significant results by sectors and periods are summarized in Table 2. All economic sectors show a statistically significant positive sensitivity to variations in the market return. Moreover, this impact is higher in the pre-crisis than in the crisis period. Sectorally, “Finance”, “Information Technology” and “Materials” show the highest market sensitivity, and “Consumer Staples” the lowest market sensitivity. This finding confirms that the market risk explains a high percentage of the variability of sectoral stock returns and, furthermore, is consistent with the previous literature.

The analysis of interest rate sensitivity indicates that five sectors (“Luxury Goods”, “Finance”, “Industry”, “Information Technology” and “Materials”) exhibit a statistically significant positive response of stock returns to non-expected nominal interest rate changes, in the whole sample. Nevertheless, if we break out our sample into two subsamples, we find different results. In the pre-crisis period, this statistically significant sensitivity is negative in three sectors (“Finance”, “Health” and “Utilities”) and positive in one sector (“Materials”), but in the crisis period we show again a statistically significant positive sensitivity in four sectors, such as “Energy”, “Industry”, “Information Technology” and “Materials”. These results in the pre-crisis period confirm that the regulated, highly indebted and financial industries are the most influenced by interest rates. Furthermore, these results are in line with previous literature (Bartram, 2002, and Ferrando *et al.*, 2015). Finally, this exposure is negative, suggesting that the stock market performance of Utilities, Finance and Health sectors clearly benefited from the context of falling interest rates. On the other hand, other sectors, such as “Information Technology”, show low interest rate sensitivity in the crisis period, because, potentially, this sort of sectors is more sensitive to crude oil price fluctuations or business cycle’s movements. Furthermore, a possible explanation of this positive interest rate exposure (according to Ferrando *et al.*, 2015) is related to the low level of interest rates. In this kind of context, interest rate increases are associated with an improving economic perspective and corporate earnings. Thus, these signals are not perceived as an inflationary threat, so that they have a helpful impact on stock prices. Finally, the

declining interest rate exposure in the crisis period suggests that other risk factors, such as the credit risk factor, might have better explained sector stock returns movements.

Our results prove that the size factor looks crucial when we analyze sectoral stock returns. Contrarily to Jareño (2008), seven US sectors show a statistically significant negative sensitivity, so the higher the size, the lower the returns. This negative sensitivity appears in all sectors in the pre-crisis period. Nevertheless, in the crisis period four sectors ("Luxury Goods", "Industry", "Information Technology" and "Materials") exhibit a statistically significant positive sensitivity to the changes in size factor and three sectors ("Health", "Telecommunications" and "Utilities") show negative sensitivity. In short, in the pre-crisis period, the "small-size" companies seem to exhibit higher stock returns than the "big-size" companies. Nevertheless, in the crisis period, only the "big-size" companies could keep high returns with economic turbulence.

Finally, the growth factor shows a positive effect on four sectors ("Energy", "Finance", "Materials" and "Utilities") and negative impact on three sectors ("Health", "Information Technology" and "Telecommunications"). When we distinguish sub-periods, we find that in the pre-crisis period all the sectors exhibit statistically significant sensitivity: positive in three sectors ("Energy", "Materials" and "Utilities") and negative in the rest of the sectors. In the crisis period, we show a positive sensitivity in 50% of the sectors ("Luxury Goods", "Finance", "Industry Sector", "Materials" and "Telecommunications"). Thus, the higher the growth opportunities, the higher the sector returns, so in the crisis period these "growth opportunities" might be a competitive advantage for the companies.

V. Concluding Remarks

This study analyzes the sensitivity of the US sectoral stock returns to the changes in interest rates, controlling for "size" and "growth opportunities" factors. Furthermore, in our analysis we distinguish two periods (before and after the start of the sub-prime crisis in the second half of 2007).

We observe large differences in the sectoral sensitivity, depending on whether we take the pre-crisis sample or the crisis sample into account. Specifically during the pre-crisis period, none of the studied sectors presents market sensitivity above unit; while during the crisis some sectors are very volatile to the changes in the market.

During the pre-crisis stage, all the sectors exhibit statistically significant negative sensitivity to changes in the size factor. This happens with the same variable growth, although in certain sectors this occurs positively ("Energy", "Materials" and "Utilities"). This suggests that prior to the crisis the size factor could be considered a competitive disadvantage, that is, the smaller the business, the bigger the yield.

The nominal interest rate factor impact on, at least, 40% of the sectors, regardless of the sample, and this significant sensitivity is mainly negative in the pre-crisis period and positive in the crisis period. Thus, this study shows that the US interest rate sensitivity is not homogeneous at sectoral level, due largely to the characteristics of individual sectors, such as growth opportunities and the size of their companies.

Finally, the results obtained in this research have relevant implications for the market participants: portfolio managers and policy-makers, mainly. Thus, a natural extension of this study consists in applying the new five-factor Fama-French model (Fama and

French, 2015), which includes two innovative and controversial factors: profitability and investment. This challenging proposal could answer to the question: does this extension achieve a better performance than the three-factor Fama-French model?

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Annexes

Table 1

Sectors Analyzed in the Study

Reference	Sector
S1	Luxury Goods
S2	Consumer Staples
S3	Energy
S4	Finance
S5	Health
S6	Industry Sector
S7	Information Technology
S8	Materials
S9	Telecommunications
S10	Utilities

Source: Compiled from the classification (GICS) established by Morgan Stanley Capital International (MSCI) and Standard & Poor's (S&P).

Table 2

**Sensitivity of Stock Returns to Variations in Nominal Interest Rates,
Market Return and Size and Growth Factors**

	STOCK MARKET RETURN			10-YEAR INTEREST RATE			SIZE FACTOR			GROWTH FACTOR		
	TOTAL	PRE-CRISIS	CRISIS	TOTAL	PRE-CRISIS	CRISIS	TOTAL	PRE-CRISIS	CRISIS	TOTAL	PRE-CRISIS	CRISIS
S1	1.0032 ^c	0.8005 ^c	1.0043 ^c	0.0495 ^c	0.0293	0.0233	-0.0012 ^c	-0.0032 ^c	0.0030 ^c	-0.0006	-0.0048 ^c	0.0051 ^c
S2	0.5542 ^c	0.4656 ^c	0.5886 ^c	-0.0134	-0.0594	0.0017	-0.0043	-0.0054 ^c	-0.0010	-0.0005	-0.0021 ^c	0.0007
S3	0.7592 ^c	0.5563 ^c	1.0911 ^c	0.0529	0.0029	0.1384 ^c	-0.0017 ^c	-0.0022 ^c	-0.0008	0.0036 ^c	0.0020 ^c	0.0016
S4	1.3212 ^c	0.9453 ^c	1.3298 ^c	0.0315 ^c	-0.0818 ^c	0.0488	-0.0042 ^c	-0.0062 ^c	-0.0025	0.0043 ^c	-0.0031 ^c	0.0152 ^c
S5	0.6989 ^c	0.5139 ^c	0.7786 ^c	0.0007	-0.0477 ^c	0.0031	-0.0047 ^c	-0.0061 ^c	-0.0020 ^b	-0.0032 ^c	-0.0064 ^c	0.0001
S6	0.9883 ^c	0.7922 ^c	1.0449 ^c	0.0663 ^c	0.0160	0.0640 ^b	-0.0016 ^c	-0.0035 ^c	0.0031 ^c	0.0002	-0.0036 ^c	0.0042 ^c
S7	1.0883 ^c	0.7998 ^c	1.0630 ^c	0.1019 ^c	0.0548	0.0822 ^c	0.0002	-0.0016 ^b	0.0028 ^c	-0.0103 ^c	-0.0163 ^c	-0.0011
S8	0.9375 ^c	0.8002 ^c	1.1066 ^c	0.1401 ^c	0.1335 ^c	0.1159 ^c	-0.0007	-0.0027 ^c	0.0055 ^c	0.0037 ^c	0.0017 ^c	0.0030 ^b
S9	0.8058 ^c	0.6863 ^c	0.7783 ^c	-0.0048	-0.0339	-0.0056	-0.0037 ^c	-0.0045 ^c	-0.0028 ^b	-0.0017 ^c	-0.0043 ^c	0.0024 ^b
S10	0.6045 ^c	0.5841 ^c	0.7168 ^c	-0.0234	-0.0611 ^b	0.0048	-0.0030 ^c	-0.0029 ^c	-0.0028 ^c	0.0032 ^c	0.0036 ^c	0.0009

Note: The sample extends from Jan. 1990 to Apr. 2013 and the following regression has been estimated using SUR methodology:

$$RS_{jt} = \alpha_j + \beta_j \cdot RCM_t + \mu_j \cdot \Delta TIN_t + \psi_t \cdot SMB_t + \phi_t \cdot HML_t + \varepsilon_{jt}$$

where RS_{jt} is the weekly return of sector j , α_j is the independent term, β_j shows the market sensitivity of sector j , RCM_t is the weekly market return, μ_j shows the sensitivity of sector j to changes in nominal interest rates, ΔTIN_t is the non-expected change in the nominal interest rate, ψ_t shows the sensitivity of the sector j to changes in the "size" factor, SMB_t shows the weekly "size" factor return, ϕ_t shows the sensitivity of the sector j to changes in the "growth" factor, HML_t is the weekly "growth" factor return and, finally, ε_{jt} is a random disturbance.

a $p < 0.10$, b $p < 0.05$, c $p < 0.01$

Figure 1

Evolution of the US Stock Market Index and the 10-year Nominal Interest Rates (1990-2013)



Source: Based on data from Standard & Poor's 500 (Federal Reserve Bank of Saint Louis) and 10-year interest rates (US Department of the Treasury).