Quantile Risk-Return Trade-Off

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Abstract: We investigate the risk-return trade-off on the US and European stock markets. We investigate the non-linear risk-return trade-off with a special eye to the tails of the stock returns using quantile regressions. We first consider the US stock market portfolio. We find that the risk-return trade-off is significantly positive at the upper tail (0.9 quantile), where the upper tail is large positive excess returns. The positive trade-off is as expected from asset pricing models. For the lower tail (0.1 quantile), that is for large negative stock returns, the trade-off is significantly negative. And for the median (0.5 quantile), the risk-return trade-off is insignificant. These results are recovered for the US industry portfolios as well as for Eurozone stock market portfolios.

Keywords: risk-return trade-off; quantile regressions; VIX; stock markets

JEL Classifications: C22; G12; G15

1. Introduction

In this paper we investigate the risk-return trade-off on the US and European stock markets. The contribution of this paper is to investigate the non-linear risk-return trade-off with a special eye to the tails of the stock returns using quantile regressions.

The previous literature has analyzed the risk-return trade-off using the VIX volatility index to measure the risk of the US stock market, cf. Adrian, Crump, and Vogt (2019), Adrian, Stockman, and Vogt (2019), and Bansal, Connolly, and Stivers (2019).

Adrian, Crump, and Vogt (2019a) consider the non-linear risk-return trade-off for 11 US industry portfolios and bonds. Their measure if risk is the VIX volatility index. Adrian, Stackman, and Vogt (2019) consider the non-linear risk-return trade-off for 30 intentional stock markets and bond. The risk measure is the VIX volatility index. They also consider the cross-sectional relation between the VIX risk premiums and macroeconomic variables. Bansal, Connolly, Stivers (2020) create stock portfolios based on their VIX betas. The long-minus-short portfolios is regressed on a dummy variable for large levels of the VIX index (above the 0.8 quantile).

Kanas (2013) detects a significantly positive risk-return relation for the S&P 500 market index when the squared implied volatility index (VIX) is allowed for as an exogenous variable in the GARCH(1,1) conditional variance equation. Empirical findings on the risk-return trade-off vary greatly in terms of the sign and significance across markets and time span. See for example the work of Baillie and DeGennaro (1990), Nelson (1991), Chan, Karolyi and Stulz (1992), Campbell and Hentschel (1992) and Glosten, Jagannathan and Runkle (1993), Corhay and Tourani-Rad (1994), Theodossiou and Lee (1995), Bali (2008), Guo and Neely (2008), Bali, Demirtas and Levy (2009), Bali and Zhou (2016), among others.

We build on the previous literature and also consider a non-linear risk-return trade-off. However, we use quantile regressions to analyze how the current stock excess returns depend on the lagged VIX volatility index. This allows us to investigate if the trade-off differs across quantiles, and we look closer at the differences between the lower tail, the median, and the upper tail.

The empirical analysis first investigates the risk-return trade-off for the US market portfolio. For the upper tail (0.9 quantile), that is the large positive excess returns, the risk-return trade-off is significantly positive. Here the empirical findings are in accordance with our expectations from asset pricing models such as the CAPM. In contrast, the empirical risk-return trade-off is significantly negative for the lower tail (0.1 quantile). And for the median (0.5 quantile) the risk-return trade-off does not exist which is similar to the findings using linear OLS. The qualitative same results also apply for US industry portfolios as well as for nine Eurozone stock markets.

The remaining part of the paper is structured as follows. Section 2 describes the data, while Section 3 contains the econometric method. The empirical results are provided in Section 4, while Section 5 concludes.

2. Data

Our data set is based on daily observations and the sample period begins on 1/1/1990 for the US and on 1/1/1999 for Europe and ends on 9/30/2020.

In Section 2.1 we describe the stock return data and in Section 2.2 the risk measures.

2.1. Stock Returns

We use stock excess returns above the risk free interest rate.

For the US we analyze the market portfolio as well as ten industry portfolios; consumer nondurables (NoDur), consumer durables (Durbl), manufacturing (Manuf), oil, gas, and coal extraction and products (Enrgy), business equipment (HiTec), telephone and television transmission (Telcm), wholesale, retail, and some services (Shops), healthcare, medical equipment, and drugs (Hlth), utilities (Utils), and other (Other). The US risk free interest rate is the 1-month Treasury bill rate.[4]

We consider the market indices from nine Eurozone countries: Belgium, Finland, France, Germany, Ireland, Italy, Luxembourg, the Netherlands and Spain.[5] We use the six month euro LIBOR interest rate as the risk free interest rate.

Table 1 shows the summary statistics for the excess stock returns. The average excess stock returns are very small and highly variable. The excess returns are close to symmetric (small, but negative skewness) while they have fat tails (large kurtosis).

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[4] The US stock returns and risk free interest rate are gratefully available from Kenneth French's data library.

[5] The Eurozone stock returns and euro LIBOR rate are available from DataStream.

[Insert Table 1]

2.2. Risk Measures

For the US stock indices, we use the VIX volatility index as the main risk variable. The VIX is based on option volatility with the SP500 as underlying.[6]

For the Eurozone stock markets, we use the European volatility index, VSTOXX, which is based on option volatility with the EURO STOXX 50 as underlying. The EURO STOXX 50 covers 50 stocks from the nine Eurozone countries under investigation.

Further, we use the conditional skewness and kurtosis for the US market index, estimated using the GARCH-M model with SGT distribution developed by Savva and Theodossiou (2018).

Table 1 shows summary statistics for the risk measures. The VIX and STOXX have similar characteristics, yet the VIX has fatter tails. They are also highly correlated, with a correlation coefficient of 0.91 for their common sample period.

3. Econometric Method

For the linear risk-return trade-off the current stock excess returns depends on the lagged risk measure, here the volatility index. The linear model implies that the influence of risk is identical for all levels of the excess stock returns. Instead, we are interested in the non-linear risk-return trade-off, where the trade-off is allowed to vary when the stock excess returns are large (positive, upper tail) and small (negative, lower tail). The quantile regression model is especially suited to investigate this particular non-linear risk-return format.

We consider the quantile risk-return trade-off between excess returns and lagged risk and we include lagged excess returns to account for any autocorrelation.[7]

$$R_{i,t} = c_{i,0} + c_{i,1}^{\tau} R_{i,t-1}^{\tau} + c_{i,2}^{\tau} VI_{t-1}^{\tau} + \varepsilon_t^{\tau}$$

where R_{it} is the return on stock *i* at time *t*, VI_{t-1}^{τ} is the relevant volatility index at time *t*-1 for the τ-quantile, and ε_t^{τ} is the error term. We consider nine quantiles, namely $\tau = \{0.1, 0.2, \cdots, 0.9\}$ and

[6] The VIX data are available from CBOE's webpage.

[7] The quantile regression estimation follows Aslanidis and Christiansen (2014).

pay special attention to the lower tail ($\tau = 0.1$), the upper tail ($\tau = 0.9$), and the median ($\tau = 0.5$). We use bootstrapped standard errors.

4. Empirical Analysis

In Section 4.1 we discuss the risk-return trade-off for the US market portfolio, while Section 4.2 is concerned with the industry portfolios. Section 4.3 analyzes the Eurozone countries. Various extensions are contained in Section 4.4 (skewness and kurtosis effects), 4.5 (horizon effects), and 4.6 (subsample analysis).

4.1. Market Portfolio

In Table 2, we consider the risk-return trade-off for the US market portfolio. First, for comparison we show the linear OLS results. Here, we see that the VIX has no bearing on the market portfolio return. The VIX coefficient is close to zero and insignificant. The lagged market return has a negative and significant coefficient. Still, the R-squared is close to zero.

[Insert Table 2]

The results are quite different, when we consider the quantile regressions. At the lower quantiles, the VIX coefficient is negative implying a negative risk-return trade-off. On the other hand, at the upper quantiles, the VIX coefficient is positive, implying a positive risk-return trade-off. The slope equality test shows that the coefficients are significantly different for the 0.1, median, and 0.9 quantiles. The coefficient to the lagged market return itself also varies across quantiles, going from positive for lower quantiles to negative at upper quantiles.

Further, the explanatory power varies across the quantiles. The pseudo *R*-squared is high for the lowest and the highest quintiles and decreases towards the median, where it is around zero. The pseudo R-squared for the 0.1 quantile is 0.12, while it is 0.16 for the 0.9 quantile.

The results for the median resemble those from the linear model. Both the linear model and the median quantile regression results resembles an average across the other quantiles.

Figure 1 shows the coefficients across the quantiles together with the 95% confidence bands. The coefficient for the lagged return is monotonically decreasing across the quantiles, while the coefficient for the lagged VIX is monotonically increasing across the quantiles. The confidence band around the VIX coefficient is very tight while it is wider for the lagged return coefficient.

[Insert Figure 1]

In Table 3, we consider the risk-return trade-off without the lagged excess return, that is for $c_{i,1}^{\tau} = 0$. We include this analysis in order to investigate if the differences across quantiles for the volatility index are caused by the changes of opposite direction for the lagged return. The risk-return trade-off results hardly change, so that the coefficient to the volatility index are about the same as before and the pseudo R-squared remain the same. For this reason we continue the following analysis with the lagged return included in the quantile regressions.

[Insert Table 3]

The results imply that when the excess market returns are large and positive, then the larger the risk as measured by the VIX volatility index is, then the larger will the future excess return be. This is the positive risk-return relationship that we would expect from the asset pricing models such as CAPM. However, when the excess return is small and negative, then the risk-return trade-off is negative, the opposite to what we would expect from asset pricing models. The two very different results for the upper and lower tails explain the results for the median and the liner model, namely that the two effects cancel out and leave an insignificant effect from the risk, i.e. from the volatility index.

4.2. Industry Portfolios

Now, we examine if the results for the overall US market portfolio also hold for the 10 industry portfolios. Table 4 shows that the results are qualitatively identical across the industry portfolios to the overall market portfolio. Also, the industry portfolios have qualitative similar risk-return behavior.

[Insert Table 4]

The coefficient to the VIX volatility index is significantly negative for the lower tail and significantly positive for the upper tail for all ten industries. For the median, the VIX coefficient is around zero for all industries and it is insignificant except for NoDur, Shops, and Hlth. The coefficient to the lagged industry portfolio is either insignificant and when it is significant it has the same sign as for the overall market portfolio. The pseudo R-squared values also resemble those for the market portfolio and the slope equality test gives rise to the same conclusion, namely that the coefficients are significantly different across the upper, lower, and median quantiles.

[Insert Figure 2]

To investigate the differences across the industries further, Figure 2 shoes the slope coefficients across the quantiles for each of the industries. For the coefficient to the lagged return we see some variation across industries, implying that the autocorrelation varies across industries. For the coefficient to the lagged VIX, there is only little variation across industries, implying that the risk-return trade-off is very similar across the ten industries. The variation across quantiles is highest for industries such as Durbl, Enrgy, HiTec, and Other,

4.3. European Market Portfolios

In Table 5 we consider the empirical risk-return trade-off for the nine European stock markets.

[Insert Table 5]

The qualitative results for the European stock markets are identical to those for the US stock market. For the lower tail, there is a negative risk-return trade-off, while it is positive at the upper tail. The effect from the lagged stock return is also similar to the US stock market. The slope equality test shows that there are significant differences between the tails. The pseudo *R*-squared values are about the same size as for the US stock market.

[Insert Figure 3]

Figure 3 shows the variation in the slope coefficients across the European countries. As for the US industry portfolios, the variation across countries in the lagged stock return coefficients is fairly wide, while the variation in the coefficient to the VSTOXX risk measure is fairly narrow. The variation across quantiles is largest for Finland and the Netherlands.

4.4. Skewness and Kurtosis Effects

In Table 6 we show the results from adding the skewness and kurtosis to the risk-return trade-off for the US market portfolio.

[Insert Table 6]

The skewness only enters significantly at the upper quantile with a negative coefficient, which implies a negative effect from higher skewness. The kurtosis is not significant at any of the quantiles.

[Insert Table 7]

In Table 7 we show the same quantile regressions for the ten industry portfolios. The skewness and kurtosis are never significant at the lower tail and at the median. At the upper tail, the skewness is significantly different for four industries (HiTec, Telcm, Shops, and Utils), while it is insignificant for the other six industries. The kurtosis is only significant for the Utils industry where the effect is negative.

Overall, the skewness and kurtosis are not very important for the risk-return trade-off.

4.5. Subsample Analysis

We investigate the potential effects from the recent financial crisis on the risk-return trade-off for the US market portfolio. For this reason, we consider two sub-samples, namely before the financial crisis (1990 to 2006) and during and after the financial crisis (2007 to 2020). We obtain similar results in the two subsample as well as for the entire sample period, both when we include and exclude the lagged market return. The explanatory power is higher in the most recent subsample than the entire period which is again higher than for the period before the financial crisis.

[Insert Table 8]

5. Conclusion

We investigate the risk-return trade-off on the US and European stock markets. We investigate the non-linear risk-return trade-off focusing on the tails of the stock returns using quantile regressions. The upper tail (0.9 quantile) contains large positive excess returns, while the lower tail (0.1 quantile) contains large negative excess returns. For the US stock market portfolio, the risk-return trade-off is significantly positive at the upper tail, while it is significantly negative at the lower tail. Therefore, only the upper tail risk-return trade-off results are in accordance with our expectations from asset pricing models such as the CAPM. The results for the median (0.5 quantile) are similar to the linear risk-return trade-off results, namely that the trade-off is not significant. We find similar empirical risk-return trade-off results for US industry portfolios as well as for Eurozone stock market portfolios.

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Table 1: Descriptive Statistics

	Mean	Median	Maximum	Minimum	Std. Dev.	Skewness	Kurtosis
US MKT	0.03	0.07	11.35	-12.00	1.15	-0.26	13.63
NoDur	0.04	0.06	10.24	-9.87	0.95	-0.19	13.49
Durbl	0.05	0.06	15.03	-14.43	1.56	-0.12	10.50
Manuf	0.05	0.08	10.83	-11.11	1.18	-0.29	12.76
Enrgy	0.04	0.03	19.33	-19.73	1.59	-0.21	17.94
HiTec	0.06	0.12	16.04	-13.18	1.61	0.16	9.61
Telcm	0.04	0.06	14.5	-9.67	1.3	0.08	12.5
Shops	0.05	0.08	10.99	-10.61	1.17	-0.07	9.68
Hlth	0.05	0.07	11.10	-9.74	1.16	-0.19	8.70
Utils	0.04	0.07	14.43	-11.61	1.07	0.13	22.09
Other	0.04	0.07	12.24	-13.38	1.38	-0.15	14.98
Belgium	0.00	0.01	8.23	-14.39	1.17	-0.60	12.62
Finland	0.00	0.00	15.33	-18.26	1.77	-0.42	11.77
France	0.00	0.03	9.91	-12.28	1.28	-0.29	9.43
Germany	0.00	0.05	16.04	-9.83	1.23	-0.05	13.10
Ireland	0.00	0.01	9.09	-13.38	1.32	-0.76	11.18
Italy	-0.01	0.01	10.47	-17.43	1.36	-0.69	13.19
Luxemburg	-0.01	0.00	10.1	-6.84	1.1	-0.27	8.7
Netherland	0.00	0.03	9.29	-10.66	1.25	-0.42	9.83
Spain	-0.01	0.03	11.74	-14.20	1.31	-0.38	10.90
VIX	19.42	17.38	82.69	9.14	8.12	2.22	11.37
Skewness	-0.33	-0.34	0.36	-1.13	0.16	-0.02	3.87
Kurtosis	4.34	4.32	5.3	4.23	0.1	2.18	13.4
VSTOXX	23.94	22.04	87.51	10.68	9.75	1.70	7.11

Notes: The table shows summary statistics for the daily excess returns for the US market, the US industry portfolios, the Eurozone stock markets, and for the risk measures, VIX, skewness, kurtosis, and VSTOXX. The sample period is 1990-2020 for the US and 1999-2020 for the Eurozone.

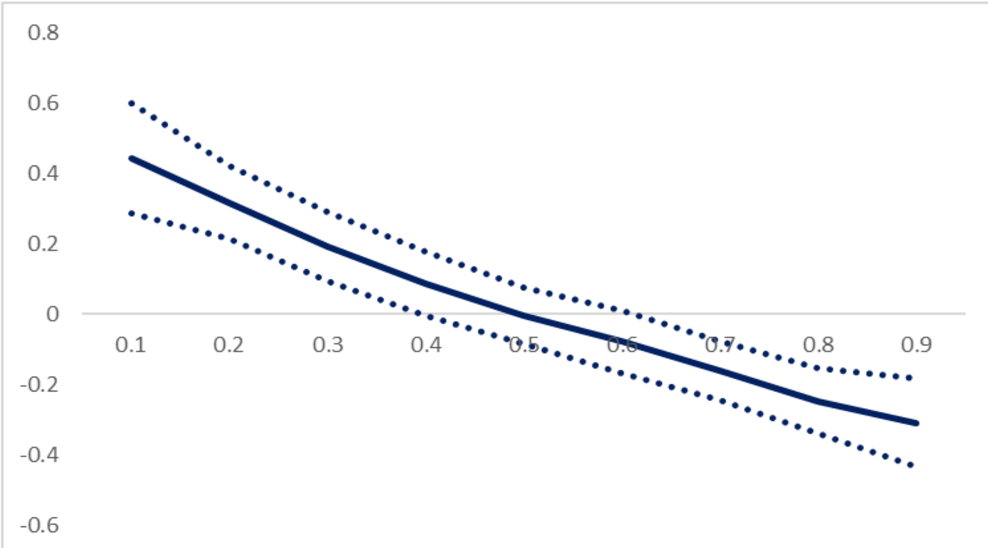
Table 2: US Market Portfolio

Quantile	OLS	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
cons	-0.03	0.44 ***	0.32 ***	0.19 ***	0.09	0.00	-0.08 *	-0.16 ***	-0.25 ***	-0.31 ***
Mkt(-1)	-0.06 **	0.07 **	0.05 **	0.01	-0.01	-0.04 **	-0.05 ***	-0.06 ***	-0.05 ***	-0.07 ***
VIX(-1)	0.00	-0.09 ***	-0.05 ***	-0.03 ***	-0.01 ***	0.00 *	0.02 ***	0.04 ***	0.06 ***	0.08 ***
Pseudo R2	0.00	0.12	0.05	0.02	0.00	0.00	0.01	0.03	0.07	0.16
Slope equality test						1067.3 ***				

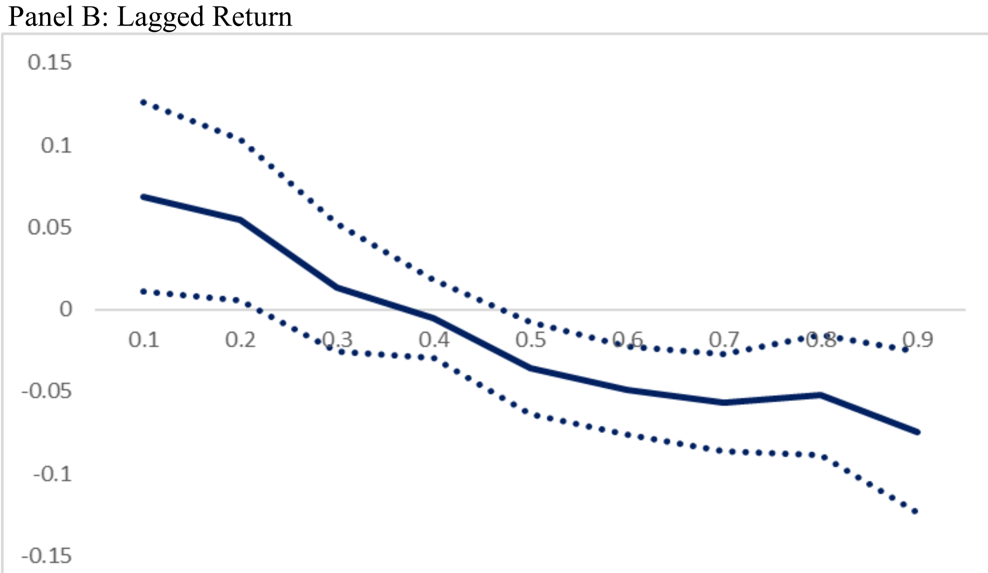
Notes: The table shows the estimation results from the OLS regression using Newey and West (1987) standard errors and the quantile regressions using bootstrapped standard errors. The LHS variable is the US market excess return and the RHS variables are its lag and the lagged VIX. The slope equality test shows the chi-square test statistic for identical slope coefficients at the 0.1, 0.5, and 0.9 quantiles. */**/*** indicates significance at 10%/5%/1% level.

Figure 1: Quantile Coefficients for US Market Portfolio

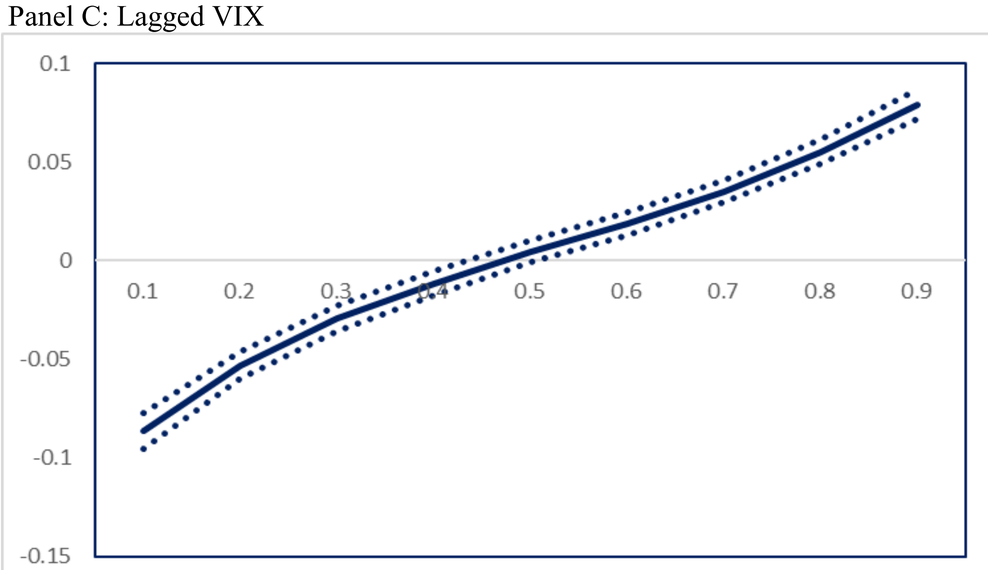
Panel A: Constant



Panel B: Lagged Return



Panel C: Lagged VIX



Notes: The figure shows the estimated coefficients from Table 2.

Table 3: US Market Portfolio

Quantile	OLS	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
cons	-0.07	0.40 ***	0.35 ***	0.21 ***	0.11 **	0.00	-0.08 *	-0.21 ***	-0.34 ***	-0.39 ***
VIX(-1)	0.00	-0.09 ***	-0.06 ***	-0.03 ***	-0.01 ***	0.00	0.02 ***	0.04 ***	0.06 ***	0.09 ***
Pseudo R2	0.00	0.13	0.06	0.02	0.00	0.00	0.01	0.03	0.08	0.17
Slope equality test						832.1 ***				

Notes: The table shows the estimation results from the OLS regression using Newey and West (1987) standard errors and the quantile regressions using bootstrapped standard errors. The LHS variable is the US market excess return and the RHS variable is the lagged VIX. The slope equality test shows the chi-square test statistic for identical slope coefficients at the 0.1, 0.5, and 0.9 quantiles. */**/*** indicates significance at 10%/5%/1% level.

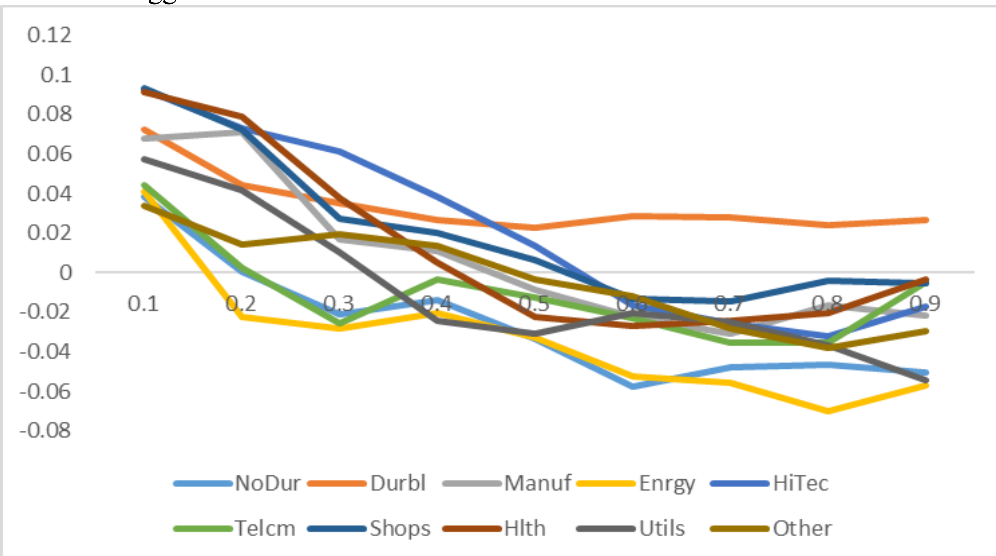
Table 4: US Industry Portfolios

Industry	Quantile	0.1	0.5	0.9	Equality test
NoDur	cons	0.09 *	-0.02	0.04	
	R(-1)	0.04	-0.03 **	-0.05 **	
	VIX(-1)	-0.06 ***	0.00 **	0.05 ***	
	Pseudo R2	0.08	0.00	0.10	694.1 **
Durbl	cons	0.05	0.03	-0.10	
	R(-1)	0.07 ***	0.02	0.03	
	VIX(-1)	-0.09 ***	0.00	0.10 ***	
	Pseudo R2	0.09	0.00	0.11	630.5 ***
Manuf	cons	0.32 ***	0.04	-0.23 ***	
	R(-1)	0.07 **	-0.01	-0.02	
	VIX(-1)	-0.08 ***	0.00	0.08 ***	
	Pseudo R2	0.10	0.00	0.14	1005.7 ***
Enrgy	cons	-0.11	-0.04	0.16 *	
	R(-1)	0.04	-0.03 *	-0.06 **	
	VIX(-1)	-0.08 ***	0.00	0.08 ***	
	Pseudo R2	0.06	0.00	0.08	488.0 ***
HiTec	cons	0.11	0.06	-0.23 ***	
	R(-1)	0.09 ***	0.01	-0.02	
	VIX(-1)	-0.10 ***	0.00	0.10 ***	
	Pseudo R2	0.09	0.00	0.12	962.7 ***
Telcm	cons	0.28 ***	-0.04	-0.27 ***	
	R(-1)	0.04 **	-0.01	0.00	
	VIX(-1)	-0.08 ***	0.01 *	0.08 ***	
	Pseudo R2	0.11	0.00	0.13	957.1 ***
Shops	cons	0.07	-0.02	-0.14 **	
	R(-1)	0.09 ***	0.01	-0.01	
	VIX(-1)	-0.07 ***	0.01 **	0.07 ***	
	Pseudo R2	0.08	0.00	0.12	920.4 ***
Hlth	cons	-0.17 **	-0.02	0.17 **	
	R(-1)	0.09 ***	-0.02 *	0.00	
	VIX(-1)	-0.06 ***	0.01 **	0.06 ***	
	Pseudo R2	0.05	0.00	0.08	348.4 ***
Utils	cons	0.08	0.04	0.06	
	R(-1)	0.06 *	-0.03 *	-0.05 ***	
	VIX(-1)	-0.06 ***	0.00	0.05 ***	
	Pseudo R2	0.08	0.00	0.09	598.3 ***
Other	cons	0.54 ***	0.04	-0.46 ***	
	R(-1)	0.03	0.00	-0.03	
	VIX(-1)	-0.10 ***	0.00	0.10 ***	
	Pseudo R2	0.13	0.00	0.16	874.9 ***

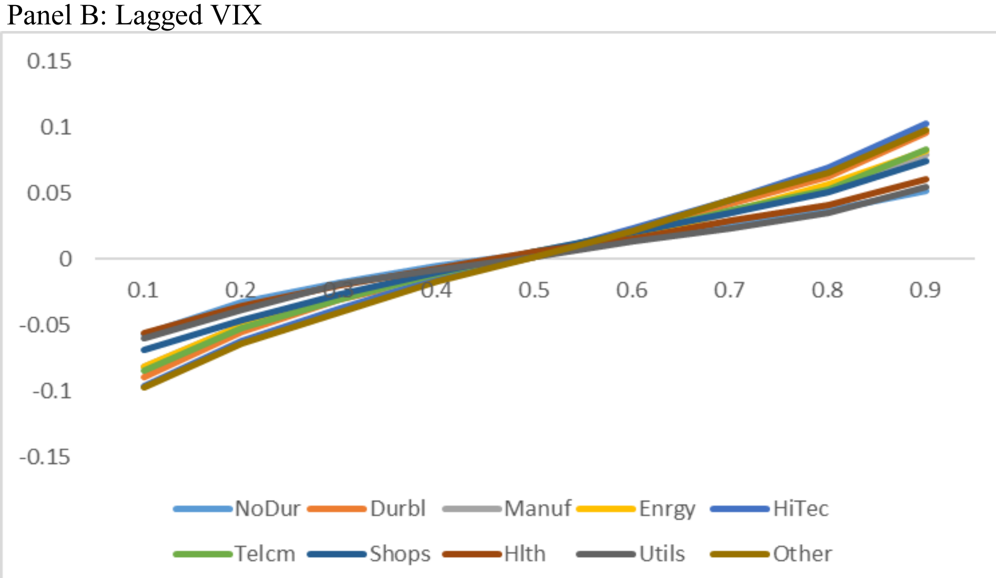
Notes: The table shows the estimation results from the quantile regressions using bootstrapped standard errors. The LHS variables are the US industry excess return and the RHS variables are their lag and the lagged VIX. The slope equality test shows the chi-square test statistic for identical slope coefficients at the 0.1, 0.5, and 0.9 quantiles. */**/*** indicates significance at 10%/5%/1% level.

Figure 2: Quantile Coefficients for US Industry Portfolios

Panel A: Lagged Return



Panel B: Lagged VIX



Notes: The figure shows the estimated coefficients from Table 4.

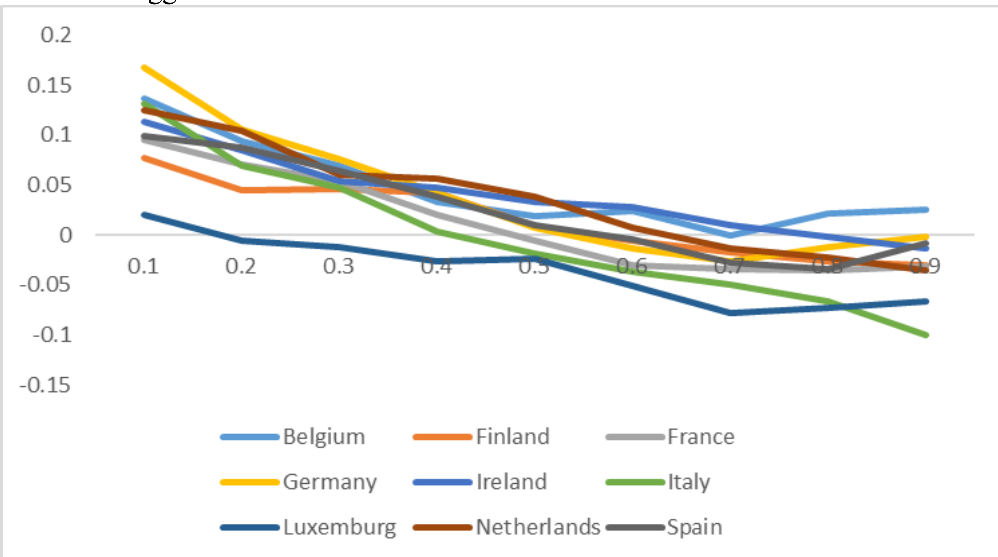
Table 5: European Portfolios

Country	Quantile	0.1	0.5	0.9	Equality test
Belgium	cons	0.05	0.02	-0.13 *	
	R(-1)	0.14 ***	0.02	0.03	
	VSTOXX(-1)	-0.06 ***	0.00	0.06 ***	
	Pseudo R2	0.10	0.00	0.10	642.5 ***
Finland	cons	0.22	-0.01	-0.37 ***	
	R(-1)	0.08 **	0.01	-0.03	
	VSTOXX(-1)	-0.09 ***	0.00	0.09 ***	
	Pseudo R2	0.09	0.00	0.12	821.7 ***
France	cons	0.33 ***	0.02	-0.28 ***	
	R(-1)	0.09 ***	-0.01	-0.03	
	VSTOXX(-1)	-0.07 ***	0.00	0.07 ***	
	Pseudo R2	0.11	0.00	0.13	813.5 ***
Germany	cons	0.13	0.04	-0.24 **	
	R(-1)	0.17 ***	0.01	0.00	
	VSTOXX(-1)	-0.07 ***	0.00	0.07 ***	
	Pseudo R2	0.10	0.00	0.12	675.9 ***
Ireland	cons	-0.13	0.01	0.20 *	
	R(-1)	0.11 ***	0.03 **	-0.01	
	VSTOXX(-1)	-0.05 ***	0.00	0.05 ***	
	Pseudo R2	0.06	0.00	0.06	254.5 ***
Italy	cons	-0.05	0.02	-0.13 **	
	R(-1)	0.13 ***	-0.02	-0.10 ***	
	VSTOXX(-1)	-0.06 ***	0.00	0.07 ***	
	Pseudo R2	0.07	0.00	0.11	616.9 ***
Luxemburg	cons	-0.46 ***	0.05 *	0.59 ***	
	R(-1)	0.02	-0.02 *	-0.07 **	
	VSTOXX(-1)	-0.03 ***	0.00 *	0.02 ***	
	Pseudo R2	0.03	0.00	0.02	105.4 ***
Netherland	cons	0.32 ***	0.04	-0.37 ***	
	R(-1)	0.12 ***	0.04 **	-0.04	
	VSTOXX(-1)	-0.07 ***	0.00	0.07 ***	
	Pseudo R2	0.12	0.00	0.14	754.8 ***
Spain	cons	-0.13	-0.01	-0.19 **	
	R(-1)	0.10 ***	0.01	-0.01	
	VSTOXX(-1)	-0.06 ***	0.00	0.07 ***	
	Pseudo R2	0.08	0.00	0.10	399.4 ***

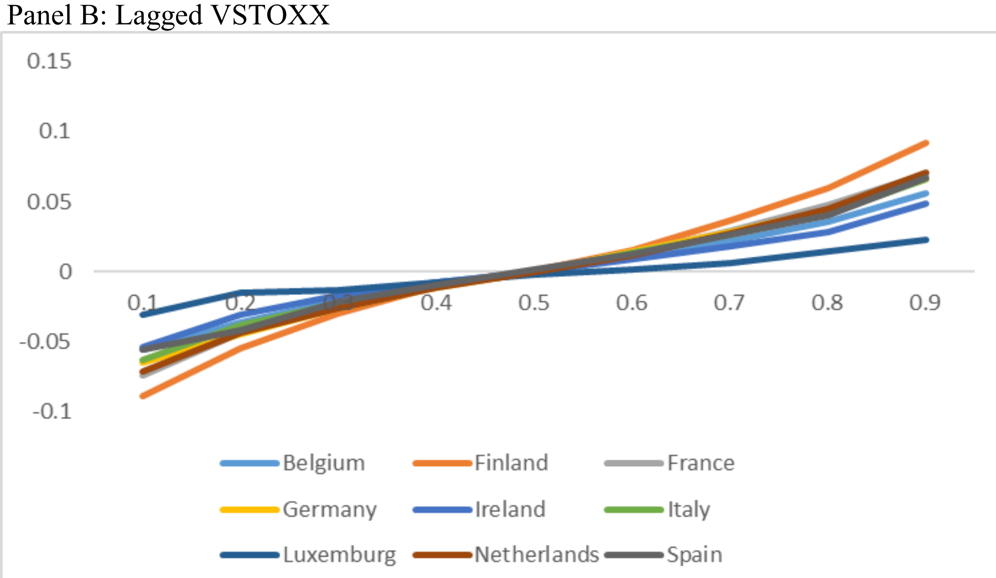
Notes: The table shows the estimation results from the quantile regressions using bootstrapped standard errors. The LHS variables are the European excess return and the RHS variables are their lag and the lagged VSTOXX. The slope equality test shows the chi-square test statistic for identical slope coefficients at the 0.1, 0.5, and 0.9 quantiles. */**/*** indicates significance at 10%/5%/1% level.

Figure 3: Quantile Coefficients for European Portfolios

Panel A: Lagged Return



Panel B: Lagged VSTOXX



Notes: The figure shows the estimated coefficients from Table 5.

Table 6: US Market Portfolio, Skewness and Kurtosis

Quantile	OLS	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
cons	1.01	4.17 *	2.02	0.78	0.73	0.92	0.22	-0.87	0.13	1.14
Mkt(-1)	-0.06 *	0.07 **	0.05 *	0.01	-0.01	-0.04 **	-0.05 ***	-0.06 ***	-0.05 ***	-0.06 **
VIX(-1)	0.00	-0.08 ***	-0.05 ***	-0.03 ***	-0.01 ***	0.00 *	0.02 ***	0.03 ***	0.05 ***	0.08 ***
Skewness(-1)	-0.17	0.12	0.07	-0.02	-0.08	-0.23 *	-0.19	-0.22	-0.42 *	-0.59 ***
Kurtosis(-1)	-0.25	-0.86	-0.39	-0.14	-0.16	-0.23	-0.08	0.15	-0.11	-0.37
Pseudo R2	0.00	0.12	0.06	0.02	0.00	0.00	0.01	0.03	0.08	0.16
Slope equality test						988.0 ***				

Notes: The table shows the estimation results from the OLS regression using Newey and West (1987) standard errors and the quantile regressions using bootstrapped standard errors. The LHS variable is the US market excess return and the RHS variables are its lag, the lagged VIX, the lagges skeweness, and the lagged kurtosis. The slope equality test shows the chi-square test statistic for identical slope coefficients at the 0.1, 0.5, and 0.9 quantiles. */**/*** indicates significance at 10%/5%/1% level.

Table 7: 10 US Industry Portfolios, Skewness and Kurtosis

Industry	Quantile	0.1	0.5	0.9	Equality test
NoDur	cons	2.84	-0.38	0.63	
	R(-1)	0.05 *	-0.03 **	-0.05 ***	
	VIX(-1)	-0.06 ***	0.00 **	0.05 ***	
	Skewness(-1)	0.01	0.03	-0.29	
	Kurtosis(-1)	-0.64	0.09	-0.15	
	Pseudo R2	0.08	0.00	0.11	920.1 ***
Durbl	cons	-2.19	-2.99	1.98	
	R(-1)	0.07 **	0.02	0.02	
	VIX(-1)	-0.09 ***	0.00	0.10 ***	
	Skewness(-1)	0.76 *	0.16	-0.38	
	Kurtosis(-1)	0.58	0.71	-0.51	
	Pseudo R2	0.09	0.00	0.11	1045.6 ***
Manuf	cons	4.96 *	1.42	0.00	
	R(-1)	0.07 ***	-0.01	-0.03	
	VIX(-1)	-0.08 ***	0.00	0.08 ***	
	Skewness(-1)	-0.17	-0.29	-0.36 *	
	Kurtosis(-1)	-1.09	-0.34	-0.07	
	Pseudo R2	0.11	0.00	0.14	1093.9 ***
Enrgy	cons	4.91	2.51	0.20	
	R(-1)	0.05 *	-0.03 **	-0.05 **	
	VIX(-1)	-0.08 ***	0.00	0.08 ***	
	Skewness(-1)	-0.29	-0.35	-0.32	
	Kurtosis(-1)	-1.19	-0.62	-0.04	
	Pseudo R2	0.06	0.00	0.08	491.1 ***
HiTec	cons	5.92	-1.63	0.81	
	R(-1)	0.09 ***	0.01	-0.02	
	VIX(-1)	-0.09 ***	0.00	0.10 ***	
	Skewness(-1)	0.06	0.16	-0.85 ***	
	Kurtosis(-1)	-1.36	0.40	-0.29	
	Pseudo R2	0.09	0.00	0.12	1099.3 ***
Telcm	cons	4.80 *	-0.67	1.36	
	R(-1)	0.05 **	-0.01	0.00	
	VIX(-1)	-0.08 ***	0.01 *	0.08 ***	
	Skewness(-1)	-0.16	0.05	-0.52 **	
	Kurtosis(-1)	-1.06	0.15	-0.41	
	Pseudo R2	0.11	0.00	0.13	849.1 ***
Shops	cons	2.87	-0.01	0.98	
	R(-1)	0.10 ***	0.00	-0.01	
	VIX(-1)	-0.07 ***	0.01 **	0.07 ***	
	Skewness(-1)	0.10	-0.05	-0.75 ***	
	Kurtosis(-1)	-0.65	0.00	-0.32	
	Pseudo R2	0.08	0.00	0.13	1095.0 ***
Hlth	cons	1.88	-0.01	-3.06	
	R(-1)	0.10 ***	-0.03 **	0.00	
	VIX(-1)	-0.05 ***	0.01 **	0.06 ***	
	Skewness(-1)	0.14	-0.10	-0.03	
	Kurtosis(-1)	-0.47	-0.01	0.74	
	Pseudo R2	0.06	0.00	0.09	543.1 ***
Utils	cons	1.82	1.78	5.30 ***	
	R(-1)	0.07 **	-0.03 **	-0.06 **	
	VIX(-1)	-0.06 ***	0.00	0.05 ***	
	Skewness(-1)	0.02	-0.32 **	-0.66 ***	
	Kurtosis(-1)	-0.41	-0.43	-1.26 ***	
	Pseudo R2	0.08	0.00	0.09	648.1 ***
Other	cons	5.24 *	-0.85	-0.77	
	R(-1)	0.05	0.00	-0.03	
	VIX(-1)	-0.09 ***	0.00	0.10 ***	
	Skewness(-1)	-0.26	0.02	-0.21	
	Kurtosis(-1)	-1.12 *	0.21	0.06	
	Pseudo R2	0.13	0.00	0.16	1173.4 ***

Notes: The table shows the estimation results from the quantile regressions using bootstrapped standard errors. The LHS variables are the US industry excess return and the RHS variables are their lag, the lagged VIX, the lagged skewness, and the lagged kurtosis. The slope equality test shows the chi-square test statistic for identical slope coefficients at the 0.1, 0.5, and 0.9 quantiles. */**/*** indicates significance at 10%/5%/1% level.

Table 8: US Market Portfolio, Subsamples

Period	Quantile	0.1	0.5	0.9	Equality test
1990-2006	cons	0.29 ***	0.01	-0.20 **	
	Mkt(-1)	0.14 ***	0.02	0.01	
	VIX(-1)	-0.07 ***	0.00	0.07 ***	
	Pseudo R2	0.10	0.00	0.10	380.8 ***
1990-2006	cons	0.30 ***	0.01	-0.19 **	
	VIX(-1)	-0.07 ***	0.00	0.07 ***	
	Pseudo R2	0.10	0.00	0.10	468.0 ***
2007-2020	cons	0.51 ***	-0.03	-0.40 ***	
	Mkt(-1)	0.01	-0.09 ***	-0.14 ***	
	VIX(-1)	-0.10 ***	0.01 **	0.09 ***	
	Pseudo R2	0.14	0.01	0.22	524.5 ***
2007-2020	cons	0.53 ***	-0.04	-0.50 ***	
	VIX(-1)	-0.10 ***	0.01 *	0.09 ***	
	Pseudo R2	0.14	0.00	0.21	553.7 ***

Notes: The table shows the estimation results from the quantile regressions using bootstrapped standard errors for three sample periods. The LHS variable is the US market excess return and the RHS variables are its lag and the lagged VIX. The slope equality test shows the chi-square test statistic for identical slope coefficients at the 0.1, 0.5, and 0.9 quantiles. */**/*** indicates significance at 10%/5%/1% level.