VIX Futures as a Market Timing Indicator

Athanasios P. Fassas[1] and Nikolas Hourvouliades[2]

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Abstract

This study contributes to the age-old question of whether stock market returns are predictable, by studying the relationship of VIX futures term structure and future S&P500 returns. The objective of this empirical analysis is to verify if the shape of the volatility futures term structure has signaling effects regarding future equity prices movements, as several investors believe. Our findings generally support the hypothesis that the term structure of VIX futures can be employed as a contrarian market timing indicator for the equity market. The empirical analysis of this study has important practical implications for financial market practitioners, as it shows that they can use the VIX futures term structure not only as a proxy of market expectations on forward volatility, but also as a stock market predictive tool.

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JEL Classification Codes: *G10, G11*

[1] Adjunct Professor, Researcher, American College of Thessaloniki; afassas@act.edu

[2] Professor, American College of Thessaloniki; hourvoul@act.edu
Address: 17 Sevenidi Str., 55510, Thessaloniki, Greece, tel: +302310398385

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I. INTRODUCTION

A fundamental principle of finance is the positive expected return-risk trade-off. In this paper we examine the dynamic dependencies between future equity returns and the term structure of VIX futures. This paper is motivated by earlier studies that examine the relationship between VIX and contemporaneous and future equity returns (e.g. Fleming, Ostdiek, and Whaley 1995; Giot 2005; Banerjee, Doran, and Peterson 2007; Chung et al. 2011) and extends the VIX futures related literature by testing the predicting ability of VIX futures term structure regarding future stock movements. We also investigate whether a steep upward-sloping term structure signals the late phase of a bullish trend and conversely, if an inverted VIX futures term structure indicates a potential stock buying opportunity.

CBOE Volatility Index (known as VIX) was introduced by Chicago Board Options Exchange (CBOE) in 1993 and was the first publicly available volatility index. In 2004, the CBOE Futures Exchange (CFE) introduced futures contracts with VIX as the underlying asset and VIX options were launched in 2006. However the simple cost-of-carry arbitrage relationship between future and spot prices cannot be obtained for VIX and its futures contracts, since VIX is not directly investable. At any current point in time, the VIX futures price represents the risk-neutral expectation of VIX at the contract's expiration and as a result, can vary significantly from the actual VIX level (Goltz and Stoyanov 2013). The difference between future and cash prices is often called roll yield and it is positive when the VIX futures term structure is in contango (when the spot price is lower than the future prices) and negative when it is in backwardation (when the spot price is higher than the future prices). Market participants call it a yield because this price differential results in a small amount being made or paid every day as the futures and the spot prices gradually converge.

One of the main factors behind VIX success in the literature and market is related with the negative and asymmetric relationship of VIX variability with the underlying S&P 500 returns. The information content of VIX, which has been extensively explored in empirical literature, is found to be useful in determining the future dynamics of the S&P 500 index (Chung et al. 2011). Since the level of VIX is calculated based on S&P500 call and put option prices, it reflects any positive or negative event that influence stock prices. Therefore, a negative shock on the stock market will drive put options prices higher and call options prices lower. Conversely, a positive shock will result in lower S&P500 put prices and higher call prices. The net result on the level of VIX, i.e. if the volatility index will rise or fall, depends on the relative size of the opposing call and put prices move. If the increase in option prices outweighs the respective decrease, VIX will increase and vice versa.

We can reasonably assume that the term structure of VIX futures embeds more information regarding the equity market dynamics than spot VIX, which is a single market-derived estimate of future realized volatility. With respect to the above framework, this study investigates two closely linked topics, that both relate with the empirical link between VIX futures term structure and equity returns. In particular, it examines the relationship between VIX futures term and future S&P500 index returns and also the possible use of VIX futures term structure as a market-timing indicator. More precisely, we examine whether a steep upward-sloping VIX futures term structure (known as contango) signals the late phase of a bullish move and conversely, whether an extreme negative term structure (known as backwardation) indicates an oversold market, as many investors believe. Understanding the dynamics of the equity returns and volatility relation has important implications for portfolio and risk management and asset pricing.

The paper proceeds as follows: the next section includes an analysis of the proposed estimation of the VIX futures term structure and its statistical attributes. Section 3 describes the empirical analysis of the relationship between VIX futures term structure and S&P500 returns, while section 4 discusses the relevant findings and their implications. Finally, section 5 includes the concluding remarks.

II. THE VIX FUTURES TERM STRUCTURE

CBOE Futures Exchange (CFE) launched VIX futures in March 2004. For a detailed description of the VIX futures market and its trading application see Fassas and Siriopoulos (2012). According to the contract specifications, the exchange "may list for trading up to nine near-term serial months and five months on the February quarterly cycle." In practice, during the first two years of trading of the VIX futures contracts (until March 8, 2006) there were four contracts listed. The CFE gradually increased the listed contracts series from four to six on March 9, 2006, to seven on April 24, 2006, to nine on October 23, 2006 and finally to ten on April 22, 2008 (this is still the number of series trading today).

The data set of the current analysis consists of the daily closing prices of spot VIX and the seven nearest VIX futures for the period from January 04, 2010 to December 29, 2017. The daily prices were retrieved from the website of the CBOE Futures Exchange (CFE). We set the beginning date of our sample in 2010 because that's the year that the average daily volume of VIX futures began to increase significantly. According to CBOE data, the average daily volume was 4,543 in 2009 (approximately at the same level compared to 2007 and 2008), while in 2010 it reached 17,430; in 2016 the average daily volume reached 238,773 contracts.

The present estimation of the VIX futures term structure – following Äijö (2008), Krylova et al. (2009) and Fassas (2012) – is conducted on each trading day by fitting a linear model of the available futures prices and spot VIX level as a function of time to maturity based on least squares criterion (spot VIX is considered as the price for VIX futures with maturity equal to zero). Fassas (2012) conducts a principal component analysis that shows that the estimated slope measure is a sufficient gauge of the VIX futures term structure. The proposed methodology of estimating the VIX futures term structure does not require an interpolation scheme in order to construct futures contracts with fixed constant maturities [see Fassas (2012) for a detailed description of the estimation process].

< Insert Exhibit 1 about here>

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Exhibit 1 reports the descriptive statistics of the estimated VIX futures term structure time-series. The estimated term structure is in units of volatility percentage points per year. Therefore, the mean VIX term structure estimate of 2.32 indicates that the level of VIX futures price increases, on average, by 2.32 volatility percentage points per one-year horizon, or about 0.193 percentage points per month. A simple t-test for means and the Wilcoxon signed ranks test for medians show that the upward sloping term structure is statistically significant (at 1% significance level). Therefore, on average, during the period under examination (January 2010 – December 2017) the VIX futures term structure is upward sloping, i.e. short-term VIX futures trade at lower price than long-term contracts.

< Insert Exhibit 2 about here>

However, the range of observations is relatively large, suggesting that the VIX futures term structure is considerably time varying. In fact, as shown in Exhibit 2, VIX futures term structure may change considerably and turn from upward sloping to downward sloping and vice versa in a limited period of time. Furthermore, although the estimated term structure tends to be upward sloping, there are also periods of downward sloping term during the time under review. For example, for the larger part of 2010 and 2011 the slope changed sign several times as stock prices experienced relatively high variability over the first two years of the bull market (that began in March 2009 and still holds). After 2012, there are relatively limited instances of backwardation with most notable one in August 2015 (during the late summer 2015 selloff which proved short-lived). Actually during the last year (2017), the VIX term structure hasn't turned negative once, as VIX reached exceptional low prices and remained in extremely low levels for an extended period of time. With VIX at such low levels, it is not surprising that VIX futures traded at a premium. Theoretically, when spot VIX is very low compared to its long-term average level, as it was true during the 2016-2017 period, VIX futures trade at a premium because market participants expect that VIX will rise in the future. Conversely, when VIX is very high, VIX futures trade at a discount, implying that spot VIX will eventually decline to its normal levels.

III. THE RELATIONSHIP BETWEEN VIX FUTURES TERM STRUCTURE AND FUTURE S&P500 RETURNS

Market participants very often use extreme levels of the VIX as a contrarian market timing indicator for the equity market. Generally, high levels of VIX are usually considered as capitulation signal that indicates under-valuation of stock prices and thus, potential buying opportunities. Conversely, abnormal low VIX levels indicate potentially excessive complacency and thus, may signal a market correction (Simon 2003). This paper extends the use of VIX as a market timing signal by examining the information content of the VIX futures term structure regarding future S&P500 returns. Since the VIX futures premium/ discount (compared to cash VIX) can be related to investors' risk aversion, it may be informative regarding future stock returns.

In order to test the relationship of stock market returns and VIX futures term structure, we run a regression analysis of the equity index returns (R_t) against the estimated slope measure ($Slope_t$). Furthermore, this relationship is tested over several frequencies (for 1 day, 1 week, 2 weeks, 1 month and 2 months) in order to test the potential different dynamics of this relationship. In order to deal with the overlapping observations problem, we employ heteroskedasticity and autocorrelation consistent Newey-West standard errors. Additionally, we separate the VIX futures term structure into positive ($Slope_t^+$) and negative ($Slope_t^-$), in order to take into consideration whether the futures term structure is in contango or in backwardation respectively. As a result, the assessment of the relationship between VIX futures term structure and future S&P500 returns is conducted using the following specification:

$$R_{t+K} = \alpha + \beta\ Slope^+_t + \gamma\ Slope^-_t + \varepsilon_t \qquad (1)$$

in which, R_{t+K} represents percentage returns in S&P500 in the subsequent K period (where K = 1 day, 1 week, 1 month and 1 quarter), $Slope^+_t$ is the VIX futures term structure on day t, if positive, and $Slope^-_t$ is the VIX futures term structure on day t, if negative.

Additionally, in order to assess if extreme values of the VIX futures term structure (positive and negative) can be used as market timing indicators, we follow the example of Giot (2005) and examine the following specification. In order to quantify extreme levels of the term structure, we use a classification based on the rolling 20 equally spaced percentiles (from 5% to 95% percentiles) of the estimated VIX futures slope at any given day t. In particular, at any given time t, we consider the information set available at that time, which is the past history of VIX term structure up to time t-1. Then $Slope_t$ is compared to these 20 equally spaced percentiles and ranked accordingly; if $Slope_t$ is very high (i.e. steep upward-sloping), then it will be ranked much closer to 20, while if $Slope_t$ is rather low (i.e. steeply backwardated) it will be ranked much closer to 1. After we have classified each daily level of the estimated term structure, we calculate the forward returns of S&P500 for 4 different investment horizons and run the following specification:

$$R_{t+K} = \delta_1 D1_t + \delta_2 D2_t + \delta_3 D3_t + \ldots + \delta_{19} D19_t + \delta_{20} D20_t + u_t \qquad (2)$$

in which, R_{t+K} represents percentage returns in S&P500 in the subsequent K period (where K = 1 day, 1 week, 1 month and 1 quarter) and $D1_t$, $D2_t$, … , $D20_t$ are dummy variables that take the value of 1 if $Slope_t$ falls into the particular percentile and 0 otherwise.

IV. EMPIRICAL RESULTS AND DISCUSSION

The usual regression statistics for Equation 1 for all four time horizons are given in Exhibit 3. In particular, we include the coefficient estimators and their Newey-West standard errors, the adjusted R-square, the F-statistic and the Durbin-Watson statistic. The coefficient of negative slope ($Slope^-_t$) has a negative sign in all cases and it is statistical significant in the three out of the four time horizons under review (except the monthly horizon). This means that whenever the estimated VIX term structure takes negative values (i.e. the VIX futures are in backwardation) the subsequent future return of S&P500 is positive. It is noteworthy that the $Slope^-_t$ coefficient increases (in absolute terms) as time horizon increases (-0.1687 for daily returns vs. -1.1809 for quarterly returns indicating that the contrarian effect is stronger in the long run. On the contrary, the coefficient of the positive term structure ($Slope^{+}_{t}$) is not statistical significant in any instance, suggesting that when the VIX futures term structure is in contango (as it normally is) there is no meaningful market timing signal for S&P500 returns. Furthermore, the coefficients of the negative slope are in all cases higher (in absolute values) than the respective coefficients of the positive slope and these differences are statistical significant. Finally, we should note that the R-squared estimates are low and ranging from 1% (for daily observations) to 3.5% (for quarterly observations), but still acceptable and noteworthy since we are talking about future returns.

< Insert Exhibit 3 about here>

The results of Equation 2 (reported in Exhibit 4) are comparable and suggest that VIX futures term structure can be used as a stock market predictive tool. In particular, the lower percentiles (D1-D4, which correspond to 5%-20% percentiles) coefficients are statistical significant in all cases and have statistically higher coefficients compared to the respective higher percentiles coefficients (which correspond to the positive values of the VIX futures term structure, i.e. when the term structure is in contango). Similarly with the results regarding Equation 1, the coefficients for the low percentiles (which correspond to the negative values of the VIX futures term structure) increase as time horizon increases. The R-squared estimates are also comparable with the respective estimates of Equation 1.

< Insert Exhibit 4 about here>

The empirical findings show that VIX futures term structure can be used as a stock market predictive tool and particularly that the negative slope of the structure can be considered as a contrarian market timing indicator. This finding seems consistent with investors' view that a downward sloping VIX term structure is as an indication of an oversold market. The VIX futures term structure will ultimately flatten out and according to the empirical history this will happen when the stock market advances. The downward sloping VIX futures term structure suggests that short-term volatility is relatively high compared to its long-term level and that investors expect a decrease in volatility in the future (Zhang et al. 2010). This may prove bullish for the stock market as there is an inverse relationship between VIX and S&P500 returns (usually when VIX declines, S&P500 advances).

In concluding, the VIX term structure besides its usefulness as a market timing signal when it is in backwardation, it can also be used for constructing trading strategies that attempt to earn the term structure risk premium, when it is in contango (which is historically the case). An investor that simultaneously buys VIX and S&P 500 Index puts for the same expiration month can capture this volatility premium. At expiration, the prices of spot and future VIX should converge, therefore, either spot VIX will rise or VIX futures price will fall. In the first case, if spot VIX advances, the VIX puts will be worthless, but, most likely, the S&P500 puts will be profitable (since when VIX rises, S&P500 falls). In the second case, if spot VIX doesn't increase, the VIX futures price will fall and the VIX puts will become profitable (since their pricing is based on the futures price and not on the cash VIX value).

V. CONCLUSION

The CBOE Volatility Index (VIX), originally introduced in 1993 and redesigned in 2003, is a widely used measure of investors' estimate of future realized volatility, as well as a "fear gauge" in the stock market (Whaley 2000). VIX futures, which were introduced in 2004, offer investors the opportunity to attain more effective exposure to volatility compared to variance swaps and delta-neutral option strategies (such as straddles and strangles).The VIX term structure, which captures the difference between the prices of short-term and long-term VIX futures contracts, should offer more information than the current VIX level, as it includes both the current level of implied volatility and the expectations regarding the future levels of implied volatility (as proxied by VIX futures). The present study contributes to the fast-growing literature on the VIX futures term structure by examining the relationship between the VIX futures term structure and S&P500 future returns. We show that our estimated term structure measure can serve as an important signal for market timing.

The initial part of our analysis involves the estimation of the VIX futures term structure and the description of its statistical characteristics. VIX futures term structure varies heavily over time as it generally tends to be upward sloping, but also persistent periods of downward sloping term structure are recorded. Subsequently, we investigate the relationship between the estimated term structure of VIX futures and the future underlying equity returns. In particular, we divide the estimated Slope price history into twenty equally spaced rolling percentiles and investigate the S&P500 future returns for four different holding periods (one day, week, month and quarter). Our main empirical finding can be summarized in the following dimension: negative VIX futures term structure indicates oversold stock prices and may signal attractive buying opportunity.

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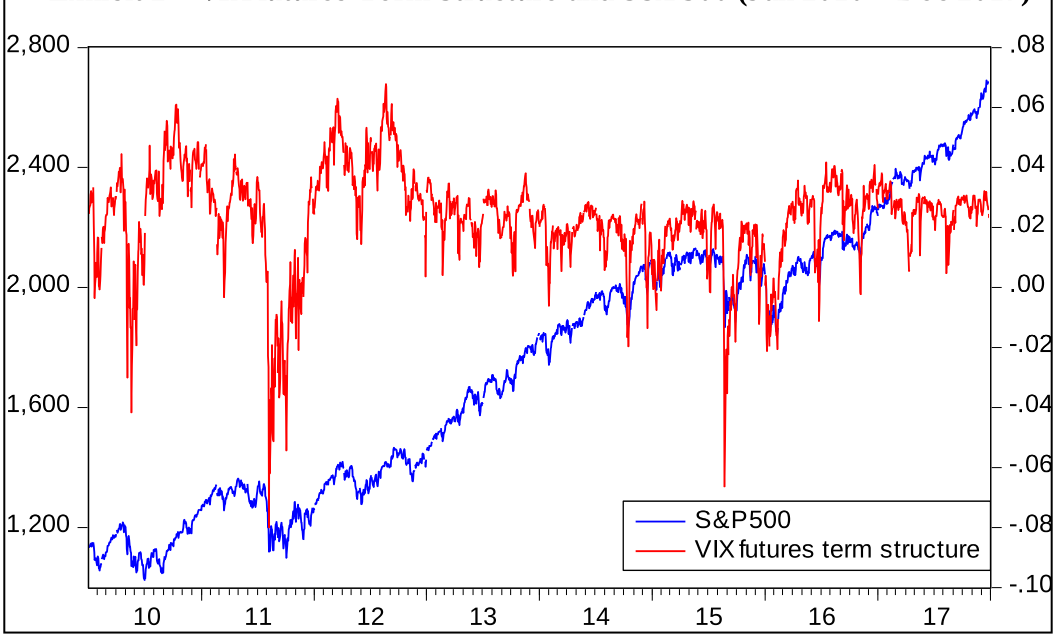
APPENDIX

Exhibit 1 – Descriptive statistics of VIX futures term structure and S&P500 returns

	Term Structure	S&P500$_{daily}$	S&P500$_{weekly}$	S&P500$_{monthly}$	S&P500$_{quarterly}$
Mean	0.0232	0.0004	0.0023	0.0093	0.0293
Median	0.0251	0.0005	0.0037	0.0135	0.0356
Maximum	0.0678	0.0463	0.0870	0.1402	0.1811
Minimum	-0.0800	-0.0690	-0.1301	-0.1647	-0.1795
Std. Dev.	0.0166	0.0093	0.0196	0.0345	0.0536
Skewness	-1.24	-0.47	-0.67	-0.76	-0.69
Kurtosis	6.87	7.84	6.71	5.09	3.75
Observations	2,013	2,013	2,008	1,993	1,949
ADF t statistic	-3.72	-47.14	-8.06	-6.24	-4.91

Note: The data set consists of the daily closing prices of VIX futures term structure and the daily, weekly, monthly and quarterly returns of S&P500 for the period from January 04, 2010 to December 31, 2017.

Exhibit 2 – VIX futures Term Structure and S&P500 (Jan 2010 – Dec 2017)



The estimation of the VIX futures Term Structure is conducted on each trading day by fitting a linear model of the available contracts and cash VIX as a function of time to maturity based on least squares criterion (spot VIX index is considered as the price for VIX futures with zero maturity). The estimated term structure is in units of volatility percentage points per year.

Exhibit 3 – VIX futures term structure and future S&P500 returns (2010 – 2017)						
Dependent variable: S&P500 returns (R_{t+K})						
	Independent Variables			**Adj. R-sq**	**F-statistic**	**DW**
	Intercept	**$Slope^{+}_{t}$**	**$Slope^{-}_{t}$**			
K = 1 day	-0.0004 (0.0007)	0.0245 (0.0208)	**-0.1687***** (0.0492)	0.9%	10.59	2.07
K = 1 week	0.0005 (0.0025)	0.0464 (0.0783)	**-0.5084***** (0.1618)	2.1%	22.81	0.46
K = 1 month	0.0112** (0.0047)	-0.1061 (0.1549)	-0.5479 (0.3393)	1.3%	14.39	0.13
K = 1 quarter	**0.0362***** (0.0066)	-0.3486 (0.2479)	**-1.1809***** (0.3171)	3.5%	35.95	0.05

Newey-West standard errors in parentheses

*** Identifies coefficient significant at the 1% level

** Identifies coefficient significant at the 5% level

* Identifies coefficient significant at the 10% level

This exhibit contains the results of the following specification that tests the relationship of VIX futures term structure with future S&P500 returns:

$R_{t+K} = \alpha + \beta\ Slope^{+}_{t} + \gamma\ Slope^{-}_{t} + \varepsilon_{t}$

in which, R_{t+K} represents percentage returns in S&P500 in the subsequent K period (where K = 1 day, 1 week, 1 month and 1 quarter), $Slope^{+}_{t}$ is the VIX futures term structure on day t, if positive, and $Slope^{-}_{t}$ is the VIX futures term structure on day t, if negative.

Exhibit 4 – VIX futures term structure percentile and future S&P500 returns (2010 – 2017)

	Dependent variable: S&P500 returns (R_{t+K})			
Independent Variables	**K=1 day**	**K=1 week**	**K=1 month**	**K=1 quarter**
D1	**0.0237****	**0.0475*****	**0.0351*****	**0.1158*****
D2	**0.0050****	0.0148*	**0.0347****	**0.0868*****
D3	0.0005	**0.0149****	**0.0307****	**0.0686*****
D4	0.0000	0.0059	**0.0281*****	**0.0580*****
D5	0.0002	-0.0051	0.0039	**0.0399*****
D6	0.0020	**0.0098****	**0.0209*****	**0.0309*****
D7	**0.0027***	0.0049	**0.0158****	**0.0435*****
D8	-0.0013	0.0002	**0.0123****	**0.0310*****
D9	0.0004	0.0026	**0.0178*****	**0.0365*****
D10	0.0006	0.0016	**0.0070****	**0.0200*****
D11	-0.0001	-0.0002	0.0044	**0.0221*****
D12	-0.0004	0.0015	0.0051	**0.0304*****
D13	0.0006	0.0021	**0.0065***	**0.0292*****
D14	0.0007	0.0005	0.0051	**0.0253*****
D15	-0.0003	-0.0001	**0.0070****	**0.0322*****
D16	-0.0009	0.0004	**0.0094****	**0.0292*****
D17	0.0004	0.0001	0.0017	**0.0204*****
D18	0.0005	**0.0037***	0.0091	0.0182
D19	**0.0011***	**0.0063*****	**0.0113****	**0.0255*****
D20	0.0008	0.0022	0.0086	**0.0222***
Adjusted R-sq	0.9%	2.9%	2.7%	4.3%

Newey-West standard errors in parentheses
*** Identifies coefficient significant at the 1% level
** Identifies coefficient significant at the 5% level
* Identifies coefficient significant at the 10% level

This exhibit contains the results of the following specification that tests the relationship of future S&P500 returns and the level of VIX futures term structure compared to its historic values:

$R_{t+K} = \delta_1 D1_t + \delta_2 D2_t + \delta_3 D3_t + \ldots + \delta_{19} D19_t + \delta_{20} D20_t + u_t$

in which, R_{t+K} represents percentage returns in S&P500 in the subsequent K period (where K = 1 day, 1 week, 1 month and 1 quarter) and $D1_t$, $D2_t$, … , $D20_t$ are dummy variables that take the value of 1 if $Slope_t$ falls into the particular percentile and 0 otherwise percentiles (percentiles are ranked from 5% to 95% in equal classes of 5%).