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Do stylized facts of equity-based volatility indices apply to fixed-income volatility indices? Evidence from the US Treasury market☆

Raquel López *

Department of Economics and Finance, University of Castilla-La Mancha, Plaza de la Universidad 1, 02071 Albacete, Spain

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ABSTRACT

In this paper, we examine whether widely documented properties of equity-based volatility indices apply to US Treasury bond volatility indices (TBVIXs). We calculate TBVIXs in a model-free way using the market prices of five-, ten- and 30-year Treasury futures options over a sample of more than 20 years. The empirical findings of this study reveal that changes in TBVIXs are positively correlated with changes in both Treasury yield rates and US non-fixed income and European equity-based volatility indices. Our analysis also shows that changes in Treasury yield rates Granger cause changes in TBVIXs and that past changes in TBVIXs help explain current changes in equity-based volatility indices (and vice versa). Finally, we find that TBVIXs fall following scheduled macroeconomic news announcements and that the response of TBVIXs to news releases depends to some extent on the magnitude and sign of the surprise in the announcement. This study's findings have implications for volatility risk management using the recently listed futures on the Chicago Board of Options Exchange's ten-year Treasury note volatility index.

1. Introduction

Since the 2003 launch of the S&P 500 volatility index (VIX) by the Chicago Board of Options Exchange (CBOE), the number of exchanges worldwide that calculate volatility indices based on stock market indices has significantly increased (see Siriopoulos & Fassas, 2009 for a comprehensive review). Thus, there exists a vast literature analyzing the properties of volatility indices in international equity markets. Several interesting stylized facts can be drawn from the research. First, there is a negative contemporaneous relationship between changes in volatility indices and the underlying stock indices' returns (see e.g., Giot, 2005; González & Novales, 2009; Whaley, 2009). Second, there is a significant contemporaneous and dynamic relationship among international equity-based volatility indices (see e.g., Äijö, 2008b; Konstantinidi, Skiadopoulos, & Tzagkaraki, 2008; Siriopoulos & Fassas, 2012). Third, volatility indices tend to fall (rise) following scheduled news announcements on macroeconomic fundamentals (unexpected events) (see e.g., Nikkinen & Sahlström, 2004a; Vähämaa & Äijö, 2011; Jiang, Konstantinidi, & Skiadopoulos, 2012).

Extending the existing literature, we investigate whether stylized facts of equity-based volatility indices apply to fixed-income volatility indices. To address our research question, we calculate three Treasury bond volatility indices (TBVIXs) with a fixed 30-day maturity using the market prices of US Treasury futures options for three different government security maturities (i.e., five, ten and 30 years). Thus, TBVIXs capture short-term market uncertainty about the development of medium- and long-term Treasury futures prices. The Treasury derivatives that we employ to calculate TBVIXs are very liquid instruments: according to the CME Group, the average trading volume in 2013 of Treasury futures and options traded at the Chicago Board of Trade (CBOT) was 3.1 million contracts per day. We construct TBVIXs based on the concept of the model-free implied variance developed by Britten-Jones and Neuberger (2000), which relies exclusively on the market prices of European options. Because Treasury futures options are American-style, one of this study's contributions is that it describes the process of calculating volatility indices using American option prices.

Although the properties of volatility indices in international equity markets are well documented in numerous papers, this question has received little attention in the fixed-income literature. To our knowledge, Markellos and Psychoyios (2013) is the only related study. However, that study differs from ours in at least three aspects. First, Markellos

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* Tel.: +34 967 599 200.
E-mail address: raquel.lopez@uclm.es.

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and Psychoyios (2013) create a set of interest rate volatility indices based on the prices of CBOE options on the spot yield of US Treasury securities. However, these options are less liquid than the Treasury futures options that we employ (Hull, 2009). Moreover, Markellos and Psychoyios (2013) use the CBOE's implementation of the model-free implied variance, which, according to Jiang and Tian (2007), may lead to several types of approximation errors. Therefore, we address the implementation issues of the model-free implied variance highlighted by Jiang and Tian (2007) for the calculation of TBVIXs. Second, Markellos and Psychoyios (2013) examine the relationship between changes in the interest rate volatility indices and VIX, whereas we consider a wider set of volatility indices, including US foreign exchange and commodity-based volatility indices and European equity-based volatility indices. Third, Markellos and Psychoyios (2013) investigate the impact of scheduled macroeconomic news announcements on the volatility indices, whereas we also analyze whether the surprise (i.e., unexpected) component of news releases helps explain movements of TBVIXs following news announcements.

The results of this study provide novel insights into the use of volatility derivatives for managing volatility risk in the Treasury market. Indeed, these insights have become a reality: in November 2014, the CBOE Futures Exchange listed futures on the CBOE's ten-year Treasury note volatility index (VXTYN). First, therefore, the positive relationship between changes in TBVIXs and Treasury yield rates, together with the negative yield-price relationship of government securities, indicates that a short (long) position in Treasury futures can be hedged by means of a short (long) position in futures on Treasury volatility indices. Moreover, we find that past changes in the yield rate help explain current changes in the TBVIX for the corresponding term to maturity. Therefore, changes in the yield rate can be used by investors who hold futures on Treasury volatility indices to improve forecasts of future movements of the underlying volatility indices. Second, the positive contemporaneous relationship of TBVIXs with other US and European volatility indices can reduce the benefits of portfolio diversification with volatility products. Third, we find evidence that changes in equity-based volatility indices can be used to improve forecasts of changes in TBVIXs (and vice versa), thereby providing valuable information for volatility risk management purposes in the equity and Treasury markets. Fourth, the significant fall in TBVIXs following employment announcements, whose dates of release are known a priori, can be used to investigate whether a benefit can be derived from investing in futures on Treasury volatility indices around the day the employment report is scheduled to be released.

The remainder of this paper is structured as follows. Section 2 reviews literature that documents some of the stylized facts of equity-based volatility indices. Section 3 presents the data set. Section 4 describes the method used to calculate TBVIXs, which is compared to the CBOE's method of calculating the ten-year Treasury note volatility index, and examines the statistical properties of the constructed volatility indices. Sections 5, 6 and 7 investigate whether the above-mentioned stylized facts of equity-based volatility indices apply to TBVIXs and discuss their implications for portfolio management. Section 8 offers the main conclusions of the study.

2. Literature review

Three salient features of volatility indices based on stock market indices are now well documented in the literature. Those features are the negative contemporaneous relationship between changes in volatility indices and the returns of the underlying stock indices; the relationship between international equity-based implied volatility indices; and the fall (rise) of volatility indices following scheduled news announcements (unexpected events). Next, we review some of the studies that address these three aspects.

2.1. The relationship between volatility indices and market returns

Academic papers contain consistent empirical evidence of a negative contemporaneous association between changes in implied volatility indices and the underlying stock indices' returns. The negative return-volatility relationship is usually explained in the literature by two different arguments. The first argument relies on the leverage effect suggested by Black (1976a), according to which a fall (rise) in equity prices increases (decreases) a firm's leverage, which in turn leads to higher (lower) equity risk and volatility. The second argument is based on the increase in the general perception of risk due to the arrival of news in the market. Such an increase may lead to selling decisions (i.e., negative returns in the equity market), which simultaneously pull the demand for put options by hedgers, thereby increasing their price and thus implied volatility.

In the US market, Whaley (2000), Simon (2003), Giot (2005) and Whaley (2009), among others, document the negative correlation for three CBOE volatility indices: VXN, VXO and VIX. With respect to European volatility indices—Siriopoulos and Fassas (2008) for VFTSE (UK); González and Novales (2009) for VDAX-NEW (Germany), VSMI (Switzerland) and VIBEX (Spain); and Siriopoulos and Fassas (2012) for GRIV (Greece)—the findings are also consistent. Ting (2007), Frijns, Tallau, and Tourani-Rad (2010) and Kumar (2012) extend the empirical evidence to Korea, Australia and India, respectively. Moreover, most studies show that the relationship between returns and implied volatility is also asymmetric: a rise (fall) in implied volatility (the equity market) has a stronger opposite effect on equity market returns (implied volatility) than does a decrease (increase) in implied volatility (equity market).[1]

2.2. The relationship among international equity-based implied volatility indices

Some studies provide evidence of a contemporaneous and dynamic correlation among the volatility indices of international equity markets. Thus, Nikkinen and Sahlström (2004b) document a positive contemporaneous relationship among changes in the volatility indices for the US, the UK, Germany and Finland, whereas implied volatility changes in the US and German equity markets lead changes in the other markets. Äijö (2008b) investigates the linkages among the volatility term structures estimated from the VDAX-NEW, VSMI and Dow Jones EURO STOXX 50 volatility index (VSTOXX), calculated from options expiring in two, six, nine and 18 months. The study reveals not only a strong contemporaneous correlation among the three implied volatility term structures but also that lags in the implied volatility term structure of the German stock market index DAX are useful for explaining the implied volatility term structures of the Swiss and Eurozone stock market indices (SMI and Dow Jones EURO STOXX 50, respectively).

Konstantinidi et al. (2008) perform a vector autoregressive (VAR) analysis based on a set of four US (VIX, VXO, VXN and VXD) and three European (VDAX-NEW, VCAC and VSTOXX) volatility indices. They find that the one-day lagged differences in some of the US volatility indices are statistically significant for explaining changes in the European ones, whereas only the French VCAC is statistically significant for explaining movements in the US volatility indices. More recently, Siriopoulos and Fassas (2012) show a leading volatility spillover effect from the German and US equity markets to the developing Greek market.

Finally, Kumar (2012) analyzes volatility transmission among three developed equity markets from three different geographic regions (the US, the UK and Japan) and an emerging market (India). The results

[1] The asymmetric relationship has been investigated in the literature treating either the stock index returns (see e.g., Whaley, 2000; González & Novales, 2009) or the relative changes in the volatility index (see e.g., Giot, 2005; Siriopoulos & Fassas, 2012) as the dependent variable.