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How does the market variance risk premium vary over time? Evidence from S&P 500 variance swap investment returns[☆]

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ABSTRACT

We explore whether the market variance risk premium (VRP) can be predicted. We measure VRP by distinguishing the investment horizon from the variance swap's maturity. We extract VRP from actual S&P 500 variance swap quotes and we test four classes of predictive models. We find that the best performing model is the one that conditions on trading activity. This relation is also economically significant. Volatility trading strategies which condition on trading activity outperform popular benchmark strategies, even once we consider transaction costs. Our finding implies that broker dealers command a greater VRP to continue holding short positions in index options in the case where trading conditions deteriorate.

1. Introduction

The variance risk premium (VRP) is the reward required by a risk averse investor for being exposed to the risk stemming from random changes in the instantaneous variance of the risky asset and from jumps in its price (Todorov, 2010; Bollerslev and Todorov, 2011). Surprisingly, there is a paucity of research on whether the market VRP is predictable.

We investigate whether the Standard and Poor's (S&P) 500 VRP can be predicted. This question is of importance for two reasons. First, it enhances our understanding of the variables that predict the total equity risk premium. This includes the equity risk premium (arising from continuous fluctuations in the price of the risky asset) and VRP (Bollerslev et al., 2009; Chabi-Yo, 2012). Second, it helps variance traders to construct profitable volatility trading strategies and to avoid taking excessive risks.[2] Typically, short volatility positions are profitable (e.g., Coval and Shumway, 2001; Bakshi and Kapadia, 2003; Driessen and Maenhout, 2007;

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2 Anecdotal evidence suggests that trading volatility has become particularly popular over the last decade. A number of products dependent on implied volatility indices such as volatility futures, volatility options and volatility exchange traded funds have been introduced. The new products improve upon the traditional class of volatility strategies conducted via index options (e.g., Alexander and Korovilas, 2013). The development of variance and volatility swap markets has also expanded the menu of volatility strategies even further. According to the Chicago Board of Options Exchange (CBOE) statistics, the trading volume in VIX options and VIX futures increased from 23,491 and 1731 contracts, respectively, in 2006 to 632,419 and 200,251 contracts, respectively, in 2014. In addition, the notional amount outstanding for index variance swaps was over USD 2 billion with USD 1.5 billion in S&P 500 VSs (Mixon and Onur, 2014).

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Ait-Sahalia et al., 2013) implying a negative market VRP. However, these positions are vulnerable to sharp increases in market volatility; this was highlighted over the recent 2008 crisis where the single names variance swap (VS) market dried up (Carr and Lee, 2009; Martin, 2013).[3]

To the best of our knowledge, only a few papers have examined whether the market VRP can be predicted. Adrian and Shin (2010) and Bekaert et al. (2013) document that broker dealers' funding liquidity and monetary policy predict VRP, respectively. However, both papers use synthesized rather than market VS rates to measure VRP. On the other hand, Bollerslev et al. (2011), Corradi et al. (2013) and Feunou et al. (2014) find that certain macro-variables, the business conditions and the term structure of the risk-neutral variance affect VRP, respectively. Nevertheless, their VRP measurement depends on the assumed parametric model and they focus on an in-sample setting. Finally, all the above studies but Feunou et al. (2014), focus on a one-month investment horizon whereas investors who trade volatility use longer investment horizons, as well.

We examine the predictability of the market VRP comprehensively. We take a unified approach by investigating whether VRP can be predicted by four model specifications: (1) the variation in the volatility of the S&P 500 returns model, (2) stock market conditions model, (3) economic conditions model, and (4) trading activity model. Theory and empirical evidence motivates this classification (see Section 2).

To address our research question, we define VRP as the conditional expectation of the return from a long position in a T-maturity S&P 500 VS contract held over an investment horizon $h \leqslant T$. The previous literature defines and measures VRP assuming that the position in a VS is held up to its maturity, i.e. $h = T$. However, in practice the position in a VS may be closed before its maturity. Our method takes this stylized fact into account and thus, it generalizes the conventional approach to measuring VRP. We calculate VRP by using a unique dataset of actual VS quotes written on the S&P 500. Previous studies measure VRP by employing synthetic VS rates synthesized using a particular portfolio of European options (e.g., Bollerslev et al., 2009, Bollerslev et al., 2014, Carr and Wu, 2009, Bekaert and Hoerova, 2014, Fan et al., 2013; Neumann and Skiadopoulos, 2013).[4]

We compute the market VRP from different T-maturity VS contracts and for different investment horizons h (term structure of VRP). Then, we conduct an in-sample as well as an out-of-sample analysis of the various model specifications. The out-of-sample setting is a useful diagnostic for the in-sample specification and it is of importance to an investor who is interested in using the models for market-timing. Hence, we perform the out-of-sample analysis using both a statistical as well as a VS trading strategy setting. Thus, we complement Egloff et al. (2010) and Ait-Sahalia et al. (2013) by providing evidence on the properties of investment strategies in the index VS markets. The previous literature has studied the performance of volatility strategies by focusing mainly on option and volatility futures markets (e.g., Coval and Shumway, 2001; Bakshi and Kapadia, 2003; Driessen and Maenhout, 2007; Konstantinidi et al., 2008).

We find that the model which conditions on trading activity variables (futures volume and TED spread) performs best. VRP increases in absolute terms (i.e. it becomes more negative) when trading activity deteriorates. We explain this as follows. Broker dealers are short in index options (Gârleanu et al., 2009) and they receive VRP as a compensation to hold these in their inventories. In the case where broker dealers face funding liquidity constraints, it is harder to take a short option position and hence, the long option investors need to offer them a greater VRP to entice them to do so. This relation holds across investment horizons and VS contracts' maturities, and it is both statistically and economically significant. VS strategies that take trading activity conditions into account outperform the buy-and-hold S&P 500 strategy and the short volatility strategy commonly used by practitioners even after we consider transaction costs. Our results extend the evidence from Adrian and Shin (2010) who find that broker dealer's funding liquidity predicts VRP.

The remainder of the paper is structured as follows. Section 2 describes the theoretical foundations and empirical evidence, which motivate the choice of models to explore the VRP predictability. Section 3 describes the data and Section 4 explains the proposed method to calculate the market VRP. Sections 5 and 6 present the in- and out-of-sample results on the statistical and economic significance of the predictors of VRP's evolution, respectively. The last section concludes.

2. Predictability of VRP: building the models

We classify the variables related to VRP in four categories: the variation of the S&P 500 volatility, the stock market conditions, the state of the economy and the trading activity. In this section, we outline briefly the relation of these variables to VRP from a theoretical as well as from an empirical perspective. For some variables, finance theory does not distinguish whether the relation between these variables and VRP is a contemporaneous or a predictive one. Nevertheless, we consider these variables as predictors to empirically test whether the relation holds in a predictive setting. For the purposes of our discussion, we fix the terminology hereafter as follows. Given that typically the market VRP is negative, we follow the VRP literature and define an increase in VRP to signify that the negative VRP becomes more negative.

2.1. Variation in the volatility of the S&P 500 returns

VRP is generated by random changes of the underlying asset's instantaneous variance stemming from two sources: the correlation (*Corr*) of variance changes with the S&P 500 returns (e.g., Cox, 1996) and the variance of volatility (*VoV*) of the S&P 500 returns (e.g., Heston, 1993; Eraker, 2008; Bollerslev et al., 2009; Drechsler and Yaron, 2011).

Corr has been documented to be negative (leverage effect). We define an increase in *Corr* to signify that the negative *Corr* becomes more negative. We expect an increase in *Corr* to increase VRP. An investor who holds a stock position pays a negative VRP as an insurance premium because the decline in the stock return can be hedged by a long position in a VS which benefits from the rise in volatility. The negative VRP becomes more negative the greater the negative *Corr* becomes because this increases the hedging effectiveness of the VS. Regarding *VoV*, we expect VRP to increase as *VoV* increases. because the greater the variation of the variance, the greater the insurance risk premium the investor is prepared to pay.

[3] A variance swap (VS) is a pure bet on variance and hence it is the natural instrument to trade variance. It is a contract that has zero value at inception. At maturity, the long side of the VS receives the difference between the realized variance over the life of the contract and a fixed rate, called the VS rate, determined at the inception of the contract (for a review of VSs, see Demeterfi et al., 1999).

[4] Alternatively, previous studies compute VRP by means of option trading strategies (e.g., Bakshi and Kapadia, 2003; Arisoy, 2010) or by taking a parametric approach where an assumed model is fitted either to market option prices (e.g., Bates, 2000, Chernov and Ghysels, 2000, Todorov, 2010; Bollerslev et al., 2011) or it is fitted to VS prices (Amengual, 2009; Egloff et al., 2010; Ait-Sahalia et al., 2013). There is also a number of studies which compute VRP by testing whether variance is priced in the cross-section of the asset returns (see e.g., Ang et al., 2006; Cremers et al., 2015). However, the computed VRP again depends on the assumed asset pricing model.