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Improving the predictability of real economic activity and asset returns with forward variances inferred from option portfolios ☆

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ABSTRACT

This paper presents an option positioning that allows us to infer forward variances from option portfolios. The forward variances we construct from equity index options help to predict (i) growth in measures of real economic activity, (ii) Treasury bill returns, (iii) stock market returns, and (iv) changes in variance swap rates. Our yardstick for measuring predictive ability is both individual and joint parameter statistical significance within a market, as well as across a set of markets.

1. Introduction

Examining the traditional hypotheses about the term structure of default-free interest rates has played a central part in financial economics (Cox, Ingersoll, and Ross, 1981; Fama and Bliss, 1987; and Campbell and Shiller, 1991). Key to these analyses are forward interest rates and bond returns, which are both based on the discount bond price representation $\mathbb{E}_t^{\mathbb{Q}}\{\exp(-\int_t^{t+\tau} r_u\, du)\}$, where τ is term to maturity, r_u is spot interest rate, and $\mathbb{E}_t^{\mathbb{Q}}\{\cdot\}$ is the time-t conditional expectation under the equivalent martingale measure $\mathbb{Q}$. If claims contingent on the exponential of integrated variance, i.e., on $\exp(-\int_t^{t+\tau} \sigma_u^2\, du)$, where σ_u^2 is instantaneous variance of equity index returns, could be valued, then one could exploit the analogy and formulate and empirically investigate a set of hypotheses linked to variance.

In this paper, we contribute by providing a framework for deducing variance-based analogues of forward interest and relating them to variations in economy-wide variables. Specifically, we ask whether forward variances can help forecast real economic activity, Treasury bill and

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bond returns, stock returns, and movements of asset prices that depend on the integrated variance of equity index returns.

We use the work of Carr and Lee (2008) to synthesize the exponential of integrated variance using a strip of European calls and puts, written on the market index. To study the predictability of asset returns and aggregate real economic activity, we employ S&P 500 index options across four maturities to build time series of prices of exponential claims on integrated variance. These prices are expressed in terms of the prices of investable portfolios of options, and hence, variance is tradable.

Crucial to our investigation are forward variances, extracted from the prices of exponential claims of different maturities. Drawing on the analogy with the term structure of interest rates, the forward variances embody expected variances, inferred from particular index option portfolios. We surmise that forward variances are related to future movements in both the financial and the real sector, as perceived in the equity index option market.[3]

Inference is based on predictive regressions, and the null hypothesis of no predictability is generally rejected, after addressing econometric concerns. Specifically, our conclusions are robust under the Newey and West (1987, 1994) method with optimal lag selection, the Hodrick (1992) approach for computing standard errors after imposing the null of no predictability, and a parametric bootstrap (i.e., Mark, 1995; Cochrane and Piazzesi, 2005; and Amihud, Hurvich, and Wang, 2009). Our yardstick for measuring predictive ability is both individual and joint statistical significance of the slope coefficients within a market, as well as across a set of markets. A simulation exercise indicates that the Hodrick (1992) test offers the correct size in small samples, under empirically relevant assumptions about the data generating process of the predictors, and even when some predictors are allowed to be nearly integrated.

Summarizing the empirical findings, a high level of front-end forward variance is associated with contracting economic activity, as measured by the growth rate of nonfarm payroll, industrial production, and other indicators. Our results suggest that forward variances are useful in predicting Treasury bill returns but fail to predict Treasury bond returns. This is the case regardless of whether the Cochrane and Piazzesi (2005) factor is used as an additional predictor.

Furthermore, some of the forward variances help to predict stock market returns in the presence of traditional predictors. The predictability is statistically significant at horizons up to six months. Finally, we find some statistically significant evidence that forward variances predict log changes in variance swap rates.

Going beyond the single-equation testing framework, we examine a system of predictive regressions, which corroborates joint predictability across markets. Overall, forward variances, extracted from index options, appear to be useful predictors of financial and real economic activity variables.

Our empirical findings should be viewed with some caution. The reason is that the construction of monthly forward variances requires index option data with a dense set of strike prices over multiple maturities, which makes us limit our study to the September 1998 to September 2008 sample period.

The paper proceeds as follows. Section 2 outlines the setup underlying the empirical investigation. Section 3 discusses the construction of forward variances. Section 4 presents evidence on the predictability of real economic activity and asset returns. Section 5 concludes the paper.

2. Exponential claims on integrated variance

Here we adopt the modeling setup of Carr and Lee (2008). Let S_t denote the level of the market index at time t and assume that S_t follows a general diffusion process under the equivalent martingale measure.

The instantaneous variance of market index return is given by the adapted process σ_t^2. In the absence of price jumps, the integrated variance of returns over an interval $[t,t+\tau_n]$ equals the quadratic variation over $[t,t+\tau_n]$, i.e., $\int_t^{t+\tau_n}\sigma_u^2\,du=\langle X\rangle_t^{(n)}$. In the empirical section, we use a set of maturities indexed by n=1,2,3,..., hence the subscript in τ_n. The dynamics of σ_t^2 is left unspecified and the riskfree interest rate r^* is constant.

We employ a special case of the generic exponential claim on integrated variance, considered in Carr and Lee (2008). Based on their Propositions 5.1 and 5.9, we specifically consider the claim with price:

$$H_t^{(t,n)}\equiv e^{-r^*\tau_n}\mathbb{E}^{\mathbb{Q}}\left\{\exp\left(-\int_t^{t+\tau_n}\sigma_u^2\,du\right)\middle|\mathcal{F}_t\right\} \tag{1}$$

$$=e^{-r^*\tau_n}\mathbb{E}^{\mathbb{Q}}\left\{\sqrt{\frac{8}{7}}\left(\sqrt{\frac{S_{t+\tau_n}}{S_t}}\right)\right.$$
$$\left.\times\cos\left(\arctan(1/\sqrt{7})+\frac{\sqrt{7}}{2}\ln\left(\frac{S_{t+\tau_n}}{S_t}\right)\right)\middle|\mathcal{F}_t\right\}, \tag{2}$$

where $\mathbb{E}^{\mathbb{Q}}\{\cdot|\mathcal{F}_t\}$ denotes $\mathcal{F}_t$-conditional expectation under the equivalent martingale measure $\mathbb{Q}$. In the double superscript $(t,\,n)$ in $H_t^{(t,n)}$, the t reflects the initiation time for the claim, while the n is associated with the time to maturity τ_n. Finally, the subscript t is the time of observation of the price, matching the time index of the information set $\mathcal{F}_t$. With the assumption that $\tau_0=0$, $H_t^{(t,0)}=1$, by definition.

[3] Our study is related to a body of literature that examines predictability in the equity, bond, and currency markets, e.g., Campbell and Shiller (1988), Ferson and Harvey (1991), Cutler, Poterba, and Summers (1991), Bekaert and Hodrick (1992), Fama and French (1993), Mark (1995), Kirby (1997), Cremers (2002), Ferson, Sarkissian, and Simin (2003), Lettau and Ludvigson (2005), Cochrane and Piazzesi (2005), Campbell and Yogo (2006), Ang and Bekaert (2007), Cochrane (2008), Boudoukh, Richardson, and Whitelaw (2008), Goyal and Welch (2008), Bollerslev, Tauchen, and Zhou (2009), Pástor and Stambaugh (2009), Henkel, Martin, and Nardari (2011), and Rapach, Strauss, and Zhou (2010). Contributions to the study of volatility expectations include Day and Lewis (1988), Stein (1989), Harvey and Whaley (1992), Canina and Figlewski (1993), Lamoureux and Lastrapes (1993), Jorion (1995), Campa and Chang (1995), Andersen, Bollerslev, Diebold, and Labys (2003), Andersen, Bollerslev, and Meddahi (2005), Aït-Sahalia and Mancini (2008), and Mixon (2009).