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# ‘Déjà vol’: Predictive regressions for aggregate stock market volatility using macroeconomic variables<sup>☆</sup>

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## ABSTRACT

Aggregate stock return volatility is both persistent and countercyclical. This paper tests whether it is possible to improve volatility forecasts at monthly and quarterly horizons by conditioning on additional macroeconomic variables. I find that several variables related to macroeconomic uncertainty, time-varying expected stock returns, and credit conditions Granger cause volatility. It is more difficult to find evidence that forecasts exploiting macroeconomic variables outperform a univariate benchmark out-of-sample. The most successful approaches involve simple combinations of individual forecasts. Predictive power associated with macroeconomic variables appears to concentrate around the onset of recessions.

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## 1. Introduction

What drives secular variation in stock return volatility? In a seminal paper, Schwert (1989) considers several potential explanations, including the possibility that volatility fluctuates with the level of economic activity.

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Although Schwert (1989) finds only limited support for links between volatility and macroeconomic activity, subsequent papers report more encouraging evidence. This large body of literature is difficult to digest, as different studies examine different forecasting variables and apply different econometric approaches.<sup>1</sup>

Understanding the robustness and magnitude of links between macroeconomic variables and volatility represents an important empirical question in finance. From a risk-management perspective, understanding how future aggregate stock market volatility responds to changing macroeconomic conditions is critical for stress-testing and computing value-at-risk over longer horizons. From an asset allocation perspective, quantities that forecast

<sup>1</sup> Relevant papers include Campbell (1987), Breen, Glosten, and Jagannathan (1989), Shanken (1990), Glosten, Jagannathan, and Runkle (1993), Whitelaw (1994), Harvey (2001), Marquering and Verbeek (2004), Lettau and Ludvigson (2010), Ludvigson and Ng (2007), Engle and Rangel (2008), Engle, Ghysels, and Sohn (2008), and Campbell and Diebold (2009).

volatility become state variables in investors' portfolio decisions. Finally, characterizing the extent and pattern of time series variation in volatility is important for determining the appropriate stylized facts against which asset pricing models should be evaluated.

Consistent with Schwert (1989) and other existing research, I find that stock return volatility behaves counter-cyclically. Empirical measures of business conditions, such as the growth rate of gross domestic product (GDP), co-move closely with sign-inverted measures of stock return volatility. From a forecasting perspective, the strong contemporaneous relation between volatility and business conditions implies that lagged volatility provides an efficient indicator of the economic state. Whether it is possible to improve forecast performance by conditioning on additional macroeconomic and financial variables is unclear. To be successful, such variables must capture information beyond that already contained in lagged volatility. This paper provides a broad assessment of the ability of macroeconomic and financial variables to improve volatility forecasts at monthly and quarterly horizons.

Recent literature identifies several channels that could drive time variation in volatility. These include time-varying volatility in shocks to fundamentals (e.g., Bansal and Yaron, 2004), nonlinear relations between time-varying expected returns and the business cycle (Mele, 2007), learning effects related to investors' uncertainty about fundamentals (e.g., Veronesi, 1999), and amplification of shocks to asset markets via financial intermediation (Brunnermeier and Pedersen, 2009). This body of theoretical work motivates the set of forecasting variables considered in the paper. These include a measure of corporate payout, several interest rate and return spreads, a measure of changes in bank leverage, measures of current and expected economic growth, a direct proxy for time-varying expected returns, volatilities for two key macroeconomic series, and two ratios for the aggregate economy: consumption to wealth and investment to capital stock.

I emphasize an out-of-sample econometric approach, although in-sample results appear for reference and comparison. This focus parallels the recent emphasis on out-of-sample inference in the literature on stock return predictability, where an active debate continues regarding the extent to which returns are predictable.<sup>2</sup> The paper distinguishes between two alternative notions of out-of-sample forecast improvement. The first focuses on properties of the data generating process: Do macroeconomic variables Granger cause volatility, such that volatility depends upon these variables conditional on past volatility? The second interpretation adopts a normative stance: Do volatility models that incorporate macroeconomic variables improve the accuracy of out-of-sample forecasts?

To see that these alternative interpretations are distinct, suppose that the conditional volatility of stock returns depends on some macroeconomic variable, so that this variable Granger causes volatility. Out-of-sample forecasts exploiting the variable could nevertheless under-perform forecasts based on a (misspecified) model that omits it. This is because there is a bias-variance trade-off at play. The conditional bias reduction afforded by including the macroeconomic predictor might not offset increased forecast variance related to parameter estimation.

I conduct two econometric tests comparing the out-of-sample forecasting performance of a benchmark model with a model augmented with one or more of the predictor variables. Both tests involve the out-of-sample difference in mean square prediction error (MSPE) relative to the benchmark. The first test, proposed by Giacomini and White (2006), is equivalent to the Diebold and Mariano (1995) test for equal predictive ability. The second test, proposed by Clark and West (2007), adds an adjustment term to the out-of-sample difference in MSPE that accounts for parameter estimation noise. The key difference between the two testing frameworks lies in the specification of the null hypothesis. In the Clark and West (2007) framework, the null hypothesis involves the population difference in MSPE between the two nested models. By contrast, the null hypothesis in the Giacomini and White (2006) framework relates to the forecasting method and explicitly incorporates parameter estimation as a source of forecast error. The Clark and West (2007) test is appropriate when the underlying research question involves Granger causality, whereas the Giacomini and White (2006) test is appropriate for addressing the normatively oriented question of whether one forecast performs better than the other.

The empirical evidence from in-sample forecasting regressions is encouraging. Several variables appear to Granger cause volatility, including the commercial paper-to-Treasury spread, the default spread, a bond return spread, and the ratio of investment to capital in the aggregate economy. The null of no predictability is also rejected for a kitchen sink specification that includes the full set of predictors. Although the statistical evidence for Granger causality is compelling, the economic significance of the predictive power afforded by these variables is relatively small. These findings are robust to several alternative sample periods, with the strength of evidence for predictability being strongest between the 1950s and early 1980s.

Out-of-sample evidence regarding Granger causality largely confirms the results from in-sample predictive regressions. The Clark and West (2007) test for Granger causality implicates essentially the same variables that are significant based on in-sample regressions. The null of no Granger causality is also typically rejected for the kitchen sink model. Results are somewhat sensitive; however, to inclusion of the economically volatile 1970s in the out-of-sample evaluation period. Specifically, the out-of-sample evidence for Granger causality is weaker over the period 1982–2010 relative to the equally long period 1972–2000 that includes the 1970s.

The evidence for superior predictive ability (in the Giacomini and White sense) is mixed. Taken one at a time,

<sup>2</sup> Goyal and Welch (2008) find little evidence that common stock return forecasting regressions succeed out-of-sample. Campbell and Thompson (2008) find that imposing economically motivated constraints on coefficients and return forecasts delivers forecast improvements relative to the historical average. Rapach, Strauss, and Zhou (2010) find that combining individual return forecasts improves out-of-sample performance.

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