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Beta forecasting at long horizons

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ABSTRACT

Systematic (CAPM beta) risk forecasting for long horizons, such as one year, plays an important role in financial management. This paper evaluates a variety of beta forecasting procedures for long forecast horizons. The widely utilized Fama-MacBeth constant beta approach based on five years of monthly returns is found to be unreliable in terms of the mean absolute (and squared) forecast error and statistical bias. The most accurate forecasts are found to be those generated from an autoregressive model of the realized beta. In addition to analyzing the statistical properties of these forecasts, this paper demonstrates the economic significance of the different approaches through an evaluation of investment projects.

1. Introduction

Accurate forecasts of the Capital Asset Pricing Model[1] (CAPM) beta at long horizons, such as one year, play an important role in financial management, including cost of capital estimations and performance measurement. Beta forecasts are usually generated by estimating the slope coefficient from a linear regression of individual stock returns on a constant and market index returns, typically using five years of monthly data as per Fama and MacBeth (1973). This method of estimating beta forecasts is the baseline for many empirical studies using the CAPM, as well as for numerous professional advisers on beta such as Bloomberg, Reuters, Standard & Poor's and Value Line.

Motivated by advances in the financial econometrics of volatility measurement, namely realized volatility measurement (see Andersen, Bollerslev, Diebold, and Ebens, 2001a; Andersen, Bollerslev, Diebold, and Labys, 2001b, 2003), CAPM realized betas were developed in the work of Barndorff-Nielsen and Shephard (2004), Andersen, Bollerslev, Diebold, and Wu (2005) and Andersen, Bollerslev, Diebold, and Wu (2006). These betas are computed over a given period from a sufficiently high number of intra-period returns, and are consistent econometrically over a fixed interval. In recent studies, CAPM realized betas have served as a benchmark for evaluating the accuracy of beta forecasting approaches; see for example Hooper, Ng, and Reeves (2008), Chang, Christoffersen, Jacobs, and Vainberg (2012), Reeves and Wu (2013), Papageorgiou, Reeves, and Xie (2016) and Cenesizoglu, Liu, Reeves, and Wu (2016). This paper conducts a forecast evaluation study with realized betas computed over periods of six months or one year, and evaluates the standard (Fama & MacBeth, 1973) forecasting approach using proposed forecasting procedures based on realized beta estimation. Chang et al. (2012) also study the same long forecast horizons for beta as this paper. However, their forecasting approach is restricted to settings in which accurate stock option data are available, whereas our study's main requirement is the availability of accurate daily stock return data, which gives it a far greater general applicability.

The primary aim of this paper is to evaluate (both statistically and economically) the performances of a variety of

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[1] See Sharpe (1964), Lintner (1965) and Mossin (1966).

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models for forecasting long horizon betas. We accomplish this by implementing two major classes of realized beta models (constant and autoregressive) and comparing their forecasting accuracies with that of the industry standard Fama-MacBeth constant five-year beta. A key feature of these forecasting approaches is their relative simplicity. This follows the fundamental principle of forecasting practice of favoring models that are not unnecessarily complicated. Even though less simple forecasting models may perform better in-sample, their performances are often less robust out-of-sample, see Green and Armstrong (2015). For this reason, this paper does not study the forecasting performances of more complicated models for beta, such as multivariate GARCH models (see Braun, Nelson, and Sunier, 1995 and Brooks and Henry, 2002) or the Bayesian model of Jostova and Philipov (2005).

Our study uses daily data from 1st January 1952 to 31st December 2011 for 15 stocks from the DJIA index, and with the DJIA index as the market portfolio. By measuring the forecast performance using the mean absolute forecast error (MAE) and the mean squared forecast error (MSE), and testing for bias in the forecasts, we find that the industry standard Fama-MacBeth constant five-year beta not only has much larger forecast errors than our other time series model, but is also downward biased, under-estimating the future value of beta.

We also test the forecast abilities of realized betas constructed from daily data of varying lengths, from six to 60 months, as well as implementing five specifications of an autoregressive realized beta model, with lags of one to five. In general, we find that both constant realized betas and autoregressive models outperform the Fama-MacBeth constant five-year beta in terms of both MAE and MSE. The best constant method, realized beta with 18 months of daily data, reduces the mean absolute error by 26.5% (25.7%) for six-month (one-year) forecasts, while the best autoregressive method, the AR(1), reduces it by 30.3% (29.8%) for six-month (one-year) forecasts relative to the standard Fama-MacBeth constant five-year beta. In addition, we also perform Mincer–Zarnowitz regressions (see Mincer and Zarnowitz, 1969) to test whether the predictions from the various forecasting models are biased. We find that the constant realized beta models and autoregressive realized beta models not only reduce the forecasting error, but also are less biased than Fama-MacBeth constant five-year betas, which are downward biased. Overall, we find an autoregressive model of the realized beta with one lag to be statistically unbiased, leading this model to be our preferred approach.

Our study focuses on Dow stocks due to their very high liquidity, which permits the use of daily historical return data going back to 1952. However, our approaches are not restricted to Dow stocks, but can be applied to any stocks that are sufficiently liquid that allow accurate daily return measurement. This set of stocks has been increasing constantly with the overall improvements in market liquidity, and typically includes sets of stocks such as those currently trading in the S&P 500 index, where daily returns over a number of years can be relied upon for most stocks.

In addition to the statistical results, this paper also demonstrates strong economic significance in an application to the cost of capital measurement and the evaluation of investment projects. In these applications, the Fama-MacBeth constant five-year betas again result in both biases and a greater variability in the cost of capital measurement, which distorts the net present value calculations. In particular, the convexity of the present value in beta means that the greater variability in the Fama-MacBeth constant five-year beta leads to the expected value of the risky asset being overstated, whereas the realized beta and autoregressive models display more favourable performances.

The rest of the paper is organized as follows. Section 2 reviews the realized beta estimator and discusses different approaches to forecasting beta at long horizons. Section 3 describes the data sources and our sample of US stocks. Section 4 investigates the empirical forecast performances of the various approaches for both the six-month and one-year forecast horizons. Section 5 demonstrates the economic significance of the different forecasting approaches by means of an evaluation of investment projects. The final section concludes the paper.

2. Realized betas and forecasting approaches

This section begins by discussing the estimation and theoretical justification of realized beta estimators, then discusses both the popular constant five-year beta forecasting approach of Fama and MacBeth (1973) and new approaches to forecasting long horizon betas, utilizing realized beta estimates.

2.1. Realized beta measurement

We begin with a brief review of the realized beta estimator and its theoretical justification, which was developed and discussed by Barndorff-Nielsen and Shephard (2004) and Andersen et al. (2006). Suppose that prices follow a multivariate continuous-time stochastic volatility diffusion, with the $N \times 1$ logarithmic vector price process p_t:

$$dp_t = \mu_t dt + \theta_t dW_t, \quad (1)$$

where μ_t is the vector of instantaneous drift, $\Omega_t = \theta_t\theta_t'$ is the diffusion (variance–covariance) matrix, and W_t represents a vector of standard Brownian motion innovations. The variance–covariance matrix and the drift vectors are not correlated with the Brownian motion process and are strictly stationary. To facilitate the interpretation, we can think of N as the number of stocks plus the market index, with the Nth element containing information on the index and each ith element containing information on stocks. By defining a time interval (for example, a day or a month) and denoting it h, we define the continuously compounded return in this period as $r_{t+h,h} \equiv p_{t+h} - p_t$.

The realized beta of a period can be defined as the realized covariance between a security and the market index divided by the realized variance of the market. If Δ is the sampling frequency, or the amount by which we divide the period h, the realized covariance during a time interval h, at time $t + h$, of a security i and the market index M, is defined as:

$$\hat{\nu}_{iM,t,t+h} = \sum_{j=1,\dots,[h/\Delta]} r_{i,t+j.\Delta,\Delta} \cdot r_{N,t+j.\Delta,\Delta}, \quad (2)$$