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Testing the value of directional forecasts in the presence of serial correlation

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ABSTRACT

Common approaches to testing the economic value of directional forecasts are based on the classical χ^2-test for independence, Fisher's exact test or the Pesaran and Timmermann test for market timing. These tests are asymptotically valid for serially independent observations, but in the presence of serial correlation they are markedly oversized, as has been confirmed in a simulation study. We therefore summarize robust test procedures for serial correlation and propose a bootstrap approach, the relative merits of which we illustrate by means of a Monte Carlo study. Our evaluations of directional predictions of stock returns and changes in Euribor rates demonstrate the importance of accounting for serial correlation in economic time series when making such predictions.

1. Introduction

Forecasts are produced in a wide range of fields, as they are important tools for decision making. The implications of a decision based on a forecast can be evaluated by means of the (expected) gain or loss associated with the decision. One loss function which is commonly used for quantitative forecasts is the quadratic loss of the forecast error. However, the squared forecast error provides only a partial assessment of economic forecasts. Diebold and Mariano (1995) point out that, in light of the wide range of economic decision problems which rely on forecasts, statistical loss functions such as the quadratic loss need not necessarily conform to economic loss functions. Granger and Pesaran (2000) discuss the relationships between statistical and economic measures of forecast accuracy, and stress that the choice of the evaluation measure should be related to the objectives of the forecast user. For example, assessing the directional accuracy (DA) of predicted directions may provide valuable insights for forecast evaluation. Lai (1990) emphasizes the fact that, even with statistically biased forecasts, an investor can still realize profits if they are on the correct side of the price change more frequently than not. Leitch and Tanner (1995) find that DA is highly correlated with profits in an interest rate setting. Since standard accuracy measures such as the mean squared or absolute forecast error (MSFE or MAFE) are less correlated with profits, they conclude that DA is a better measure of forecast accuracy for firms' profit maximization. Ash, Smith, and Heravi (1998) note that qualitative statements such as "the economy is expanding" or "the economy will be contracting in the near future" are important prerequisites for an appropriate implementation of monetary and fiscal policy. Öller and Barot (2000) point out that DA is of interest for central banks, as a forecast of increased inflation (above target) would prompt central banks to raise interest rates, for example.

An approach to the assessment of directional forecasts which is linked to the loss functional approach but not equivalent is based on the work of Merton (1981). He proposes an equilibrium theory for the economic value of

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market timing skills and provides a statistic for measuring this value. Cicarelli (1982) uses the statistical measure to analyze turning point errors. Breen, Glosten, and Jagannathan (1989), Havenner and Modjtahedi (1988), Lai (1990), Schnader and Stekler (1990) and Stekler (1994) were among the first to apply Merton's theory to the evaluation of the economic value of directional forecasts. More recent applications include, inter alia, those of Ash et al. (1998), Ashiya (2003, 2006), Easaw, Garratt, and Heravi (2005), Mills and Pepper (1999), Öller and Barot (2000) and Pons (2001). Considering realized and forecasted directions as binary variables, Merton's theory implies that directional forecasts have no value if the directional outcomes and forecasts are independent. Henriksson and Merton (1981) propose statistical procedures for evaluating forecasting skills that are in fact related to Fisher's exact test (Fisher, 1934) for testing whether two binary variables are independent. Similarly, the classical asymptotic χ^2-test for independence and the asymptotic test for market timing introduced by Pesaran and Timmermann (1992, PT92 henceforth) can also be used for testing the economic value of directional forecasts. However, these tests are derived under the assumption of serial independence. As we show later, they are seriously oversized in the presence of serially correlated forecasted or realized directions.

Recently, Pesaran and Timmermann (2009, PT09 henceforth) introduced statistics for testing for dependence among serially correlated multi-category variables which can also be used to test for the economic value of directional forecasts in the more realistic situation of serial correlation. However, in a Monte Carlo simulation study based on real-valued autoregressive processes, their test procedures reveal some small sample size distortions, which were confirmed for Markov processes by Chou and Chu (2011). In this paper, we summarize and analyze the size and power properties of a battery of tests for the economic value of directional forecasts in the presence of serial correlation. Furthermore, we also propose a bootstrap test procedure in order to reduce size distortions in small samples. In a simulation study, we show that the bootstrap test is robust to serial correlation and has appealing power properties. Moreover, it can easily be extended to multi-categorical data.

The remainder of the paper is organized as follows. We briefly review Merton's approach in the next section. In Section 3, existing test procedures and the bootstrap approach are summarized. Section 4 documents a Monte Carlo study which aims to analyze the size and power properties of the various tests. Section 5 provides two empirical applications, and Section 6 concludes. Technical details of the implementation of the bootstrap are then given in the Appendix.

2. Merton's framework for evaluating directional forecasts

Merton (1981) proposes an equilibrium theory for the value of market timing skills. In the context of evaluating directional forecasts for a (continuous) variable of interest $\widetilde{Y}_t$, let $Y_t = 1$ denote a realized upward movement of $\widetilde{Y}_t$ and $Y_t = 0$ denote a realized downward movement. Forecasted upward and downward movements are denoted by $\widehat{Y}_t = 1$ and $\widehat{Y}_t = 0$, respectively. It is assumed that the forecasts $\widehat{Y}_t$ are determined by means of information that is available up to time $t-1$. A directional forecast has no value in the sense of Merton (1981) if and only if

$$\mathbb{P}[\widehat{Y}_t = 1|Y_t = 1] + \mathbb{P}[\widehat{Y}_t = 0|Y_t = 0] = 1, \qquad (2.1)$$

where $\mathbb{P}[\widehat{Y}_t = 1|Y_t = 1]$ ($\mathbb{P}[\widehat{Y}_t = 0|Y_t = 0]$) denotes the conditional probability of a correct forecast of an upward (downward) movement. To alleviate the issue of notation, we define $HM = \mathbb{P}[\widehat{Y}_t = 1|Y_t = 1] + \mathbb{P}[\widehat{Y}_t = 0|Y_t = 0]$. For example, if $\widehat{Y}_t$ and Y_t are independent, then $\mathbb{P}[\widehat{Y}_t = 1|Y_t = 1] = \mathbb{P}[\widehat{Y}_t = 1]$ and $\mathbb{P}[\widehat{Y}_t = 0|Y_t = 0] = \mathbb{P}[\widehat{Y}_t = 0]$. Consequently, $HM = 1$ and such directional forecasts have no value. In particular, naïvely forecasting only one direction, say $\widehat{Y}_t = 1\ \forall t$, has no value.

Moreover, Merton (1981) points out that directional forecasts have positive value if and only if

$$HM > 1,$$

and that the larger HM, the larger the value. In addition, it can be shown that

$$HM - 1 = \frac{\text{Cov}\left(\widehat{Y}_t, Y_t\right)}{\mathbb{V}\left[Y_t\right]},$$

where $\text{Cov}(\widehat{Y}_t, Y_t) = \mathbb{P}[\widehat{Y}_t = 1, Y_t = 1] - \mathbb{P}[\widehat{Y}_t = 1]\mathbb{P}[Y_t = 1]$ and $\mathbb{V}[Y_t] = \mathbb{P}[Y_t = 1] - \mathbb{P}[Y_t = 1]^2$ denote the covariance between $\widehat{Y}_t$ and Y_t and the variance of Y_t, respectively. Hence, the value of the forecasts can be assessed by means of the covariability of the realized and forecasted directions. In particular, directional forecasts (i) have no value if and only if $\text{Cov}(\widehat{Y}_t, Y_t) = 0$; and (ii) have value if and only if $\text{Cov}(\widehat{Y}_t, Y_t) > 0$. Moreover, (iii) for a given process $\widetilde{Y}_t$ and hence Y_t, it holds that the larger $\text{Cov}(\widehat{Y}_t, Y_t)$, the larger the value.

Furthermore, maximizing $\text{Cov}(\widehat{Y}_t, Y_t)$ is not equivalent to maximizing the probability of a correct directional forecast $\mathbb{P}[Z_t = 1]$, where $Z_t = I(\widehat{Y}_t = Y_t)$ and $I(\bullet)$ is an indicator function. From the relationship

$$\text{Cov}\left(\widehat{Y}_t, Y_t\right) = \frac{1}{2}\mathbb{P}[Z_t = 1] + \mathbb{P}[\widehat{Y}_t = 1]\left(\frac{1}{2} - \mathbb{P}\right.$$
$$\left.\times [Y_t = 1]\right) + \frac{1}{2}\left(\mathbb{P}[Y_t = 1] - 1\right),$$

it can be seen that the correspondence between $\text{Cov}(\widehat{Y}_t, Y_t)$ and $\mathbb{P}[Z_t = 1]$ is not monotonic. Consequently, if the probability of a correct forecast $\mathbb{P}[Z_t = 1]$ increases and the probability of an upward movement forecast $\mathbb{P}[\widehat{Y}_t = 1]$ changes, then

$$\Delta\text{Cov}\left(\widehat{Y}_t, Y_t\right) = \frac{1}{2}\Delta\mathbb{P}[Z_t = 1] + \Delta\mathbb{P}[\widehat{Y}_t = 1]$$
$$\times\left(\frac{1}{2} - \mathbb{P}[Y_t = 1]\right),$$

with Δ denoting the total difference operator. Whether $\text{Cov}(\widehat{Y}_t, Y_t)$ increases or not depends on the signs and magnitudes of $\Delta\mathbb{P}[\widehat{Y}_t = 1]$ and $\left(\frac{1}{2} - \mathbb{P}[Y_t = 1]\right)$.