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FORECAST PRETESTING AND CORRECTION

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ABSTRACT: Sometimes it is suggested that end users can improve forecasts by some kind of corrections. At least implicitly the idea is to use such corrections if the forecasts appear too inaccurate by some criteria. Alternative forecasts can be defined based on whether a preliminary test of forecast usefulness and a subsequent correction has been made. The mean squared errors of some such forecasts are studied using some recent results on inequality pretesting. Uncorrected forecasts are shown to perform reasonably well. The optimal minimax regret critical values for the preliminary tests are fairly high, implying that the hypothesis of forecast usefulness should mostly be accepted and uncorrected forecasts used.

KEY WORDS: Forecast evaluation, suboptimal forecasts, forecast correction, inequality pretesting.

1. Introduction

When published macroeconomic or industry-level forecasts are used as explanatory variables in forecasting models at a less aggregate level, e.g. at the firm or regional level, one faces the problem that these forecasts may be fairly inaccurate and therefore not necessarily useful. It would be important to be able to test whether a forecast is accurate enough in such situations. For example, in a recent survey of forecasting methods in marketing, Armstrong et al. (1987) posed the question "what are acceptable levels of forecast errors for environmental inputs to market forecasting models?" as one issue where more research is needed.

One answer to this question was provided by Ashley (1983,1985). His idea was to compare use of the forecast in the model and use of the mean of the variable as an alternative forecast. In some cases this can be interpreted as omission of the variable in question from the model in the forecasting period (but not in the estimation period). For example, when the model is expressed in terms of deviations from the means, the alternative can be to forecast the deviation to be zero. Ashley's test involves a comparison of the mean squared error of the original forecast and the variance of the variable to be forecasted. If their ratio is above one, the mean of the variable is the preferable forecast. When the variables are changes and the mean is zero, the square root of Ashley's ratio is the same as Theil's (1966) inequality statistic, which is the ratio of the root mean squared errors of the original forecast and a no-change forecast. There is also related work, where similar decision rules have been derived for economic agents. (See Nelson 1961, Tisdell 1971, Ilmakunnas 1987.) The analogy to the econometric results follows from a quadratic objective function in the models.

Below a simple test is suggested which involves a regression of past realized values on the forecasts and a constant and a test of whether the slope coefficient b is greater than 1/2 (see also Ilmakunnas 1987, 1989). If $b < 1/2$, the mean of the variable is a better forecast than the original forecast after a correction for an additive bias. This approach has the advantage that the hypothesis can be tested with a t-test. When the mean is zero and the variable is regressed on the forecast without a constant, the $b < 1/2$ criterion is actually the same as Ashley's criterion. In other cases, the test is probably less likely to reject the usefulness of a forecast than Ashley's test.

Sometimes it is also suggested that published macroeconomic forecasts should be corrected by forecast users if the forecasts are fairly inaccurate in a systematic way. Typically these corrections are based on coefficients estimated from past forecast performance. (See Theil 1966, and Ashley 1985. In an economic model this has been suggested by Johansen 1978.) Positive results from empirical applications of such corrections have been reported e.g. by Ahlburg 1984 and Brandon et al. 1983; negative results were obtained by Bohara et al. 1987. Whether such corrections are to be made presumably depends on tests of forecast accuracy, although this is not always explicitly stated. Little attention has been devoted to the fact that the forecast error of the revised forecast depends not only on events in the forecast period, but also on the preliminary tests of forecast accuracy and the error made in estimating the correction factors from past data. (See, however, Clemen 1986, and Trenkler and Liski 1986, for this kind of analysis in the case of combining forecasts.) Therefore a natural way to analyze decisions on whether to use a forecast or not, and whether to correct the forecast or not, is a pretesting approach to forecast evaluation.

Below the choice between using a forecast, the mean of the variable, or a corrected forecast is studied. One alternative is to choose between the original forecast and the mean, depending on the result of the preliminary test of $b \geq 1/2$. Another case is such that either the original or the corrected forecast is used and the choice again depends on the preliminary test. The out-of-sample mean squared errors of the different alternatives are compared and the scope for forecast improvement is analyzed. The results show that forecasts that have not been revised perform reasonably well. It is also shown that the optimal significance level in the pretest may be small, which supports the use of uncorrected forecasts.

In section 2 of this paper the framework for comparing the forecasts is set out, the cases where a ranking of the forecasts is possible are discussed, and the optimal significance level in the pretest is studied. In section 3 some possible generalizations and extensions are discussed. Finally, section 4 concludes the paper by discussing the implications to forecast practitioners.

2. Pretesting and correction of forecasts

Above it was suggested that it may be possible to test whether a macro forecast is useful as an input to a forecasting model. In practice the test would be conducted using past forecasts and realizations. The result of the test would then determine what kind of forecast is used in the out-of-sample period. This leads to a pretesting approach to forecast evaluation and use.

Often forecast evaluation is made using a regression like $x_t = a + bx_t^f + v_t$, where x is the variable to be forecasted and x^f is a published forecast. The error v_t is assumed to be normally distibuted with zero mean and variance Var(v). It is further assumed that b > 0 so that, if the variables are changes, the direction of change is in general correctly forecasted. Here the model is analyzed in a deviations from the means form

$$x_t - E(x) = b(x_t^f - E(x^f)) + v_t \ , \quad t=1,\ldots,T-1 \qquad (1)$$

so that the constant term can be ignored. The period T variable to be forecasted is x_T-E(x) and its alternative forecasts are denoted f_i. Several alternatives are considered. First, assume that the original forecast has no additive bias or has been corrected for it, as in Ashley (1985), so that x_T^f + bias = $x_T^f + E(x-x^f)$ is used as a forecast of x_T. The forecast f_1 is then

$$f_1 = x_T^f + E(x-x^f) - E(x) = x_T^f - E(x^f). \qquad (2)$$

Second, x_T can be forecasted to be equal to E(x), the mean of x, i.e.

$$f_2 = E(x) - E(x) = 0. \qquad (3)$$

This will be called the mean forecast or the zero forecast. In Ilmakunnas (1989) the following criterion is suggested for choosing between f_1 and f_2: estimate b in model (1), i.e. using past data run a regression of $x-E(x)$ on $x^f-E(x^f)$ (or x on x^f and a constant). Let b^* denote the OLS estimate of b, σ^* its estimated standard error and σ the true, unknown standard error. Using b^* and σ^*, test the hypothesis H_0: $b > 1/2$. If H_0 is rejected, it is better to use forecast f_2 than forecast f_1, since $MSE(f_1) > MSE(f_2)$, and if H_0 is accepted, f_1 is used, since $MSE(f_1) < MSE(f_2)$ (see below for details). This leads to what will be called the pretest forecast. This is also the approach used in a different form in Ashley (1983). The forecast can be written as

$$f_3 = I_{(-\infty,c)}(g)f_2 + I_{[c,\infty)}(g)f_1 = I_{[c,\infty)}(g)f_1 = (1 - I_{(-\infty,c)}(g))f_1 \qquad (4)$$

where $I_{(c1,c2)}(g)$ is an indicator function that gets value one if $g=(b^*-1/2)/\sigma^*$, the t-test statistic for testing H_0, falls in the interval (c1,c2) and is zero otherwise.

The fourth alternative is such that if H_0 is rejected, and hence f_2 is preferred to f_1, Theil's (1966) linear correction is applied. This involves estimation of b in (1) and use of the corrected forecast $b^*(x_T^f-E(x^f)) = b^*f_1$. If H_0 is accepted, f_1 is used. This is the approach suggested in Ashley (1985) in a slightly different form. The resulting forecast will be called the pretest corrected forecast and can be written as

$$f_4 = I_{(-\infty,c)}(g)b^*f_1 + I_{[c,\infty)}(g)f_1 = (1 + (b^*-1)I_{(-\infty,c)}(g))f_1 \ . \qquad (5)$$

Finally, the fifth alternative is to always correct the forecast f_1

with the estimated slope coefficient from (1), i.e.

$$f_5 = b^*(x_T^f - E(x^f)) = b^* f_1 \quad . \qquad (6)$$

Other pretest forecasts could also have been considered. One possibility is to test first H_0: b=1. If this were accepted, forecast f_1 would be used, and if it were rejected, the corrected forecast b^*f_1 would be chosen. This is a special one forecast case of the model in Trenkler and Liski (1986) where several alternative forecasts are combined using the regression method. However, in this paper the purpose of the pretesting is to find out whether forecast f_1 is useful compared to the mean forecast, and not whether f_1 is an optimal forecast.

The alternative forecasts can be interpreted as forecasts $b_i(x_T^f - E(x^f)) = b_i f_1$, $i=1,\dots,5$. In case 1, the constraint $b_1=1$ is used and case 2 is constrained by $b_2=0$. In alternative 3, $b_3=1-I_{(-\infty,c)}(g)$, in alternative 4, $b_4=1+(b^*-1)I_{(-\infty,c)}(g)$ and in case 5, $b_5=b^*$. Since b_i is always either fixed a priori or estimated from past observations, it can be treated as uncorrelated with period T values of the variables. It is therefore possible to write $E(b_i(x_T^f - E(x^f))) = E(b_i)E(x_T^f - E(x^f)) = 0$.

It is useful to write b_3 in the following way:

$$b_3 = 1 - I_{(-\infty,c)}((b^*-\tfrac{1}{2})/\sigma^*) = 1 - I_{(-\infty,c)}((\sigma/\sigma^*)((b^*-b)/\sigma+\delta/\sigma))$$

$$= 1 - I_{(-\infty,(\sigma^*/\sigma)c+\delta/\sigma)}((b^*-b)/\sigma) = 1 - I_{(-\infty,d)}(u) \qquad (7)$$

where $\delta=b-1/2$ and $d=(\sigma^*/\sigma)c+\delta/\sigma$; $u=(b^*-b)/\sigma$ has standard normal distribution and $\tau(\sigma^*/\sigma)^2$ has chi-squared distribution with τ degrees of freedom (here τ=T-2).

Similarly,

$$b_4 = 1 + (b^*-1)I_{(-\infty,c)}((b^*-\tfrac{1}{2})/\sigma^*) = 1 + (b^*-1)I_{(-\infty,d)}(u)$$

$$= 1 + (b-1)I_{(-\infty,d)}(u) + \sigma I_{(-\infty,d)}(u)u \qquad (8)$$

where the equality $b^*=\sigma u+b$ has been used.

Consider now the mean squared errors of the forecasts. The MSE of the ith forecast of $x_T-E(x)$ is, using (1),

$$MSE(f_i) = E((x_T-E(x)) - b_i(x_T^f-E(x^f)))^2 = E((b-b_i)(x_T^f-E(x^f)) + v_T)^2$$

$$= E(b-b_i)^2 Var(x^f) + Var(v) \qquad (9)$$

where it has been assumed that $E(x_T^f-E(x^f))v_T = 0$. This assumption is not quite innocent, although it is practice often adopted in analyses of forecast evaluation or combination of forecasts. Actually $E(x_T^f v_T) = 0$ holds for optimal forecasts, but not necessarily for suboptimal ones.

Expression (9) shows that the alternatives can be compared in terms of $E(b-b_i)^2$, which will be denoted M_i. In cases 1 and 2 the result is straightforward:

$$M_1 = E(b-b_1)^2 = (b-1)^2 \qquad (10)$$

and

$$M_2 = E(b-b_2)^2 = b^2 . \qquad (11)$$

For the pretest forecast

$$M_3 = E(b-b_3)^2 = (b-1)^2 + 2(b-\tfrac{1}{2})EI_{(-\infty,d)}(u), \qquad (12)$$

where the fact has been used that the square of the indicator function is the indicator function itself. Using the expectation of the indicator function, given in Judge et al. (1985) and Judge and Yancey (1986), (12) can be written as

$$M_3 = \begin{cases} (b-1)^2 + (b-\tfrac{1}{2})P_1 & \text{if } d \leq 0 \\ (b-1)^2 + (b-\tfrac{1}{2})(2-P_1) & \text{if } d > 0 \end{cases} \qquad (13)$$

where the following notation has been used $P_k = Pr(\chi^2_{(k)} \geq d^2)$, i.e. the probability that a chi-square random variable with k degrees of freedom is greater than $(c\sqrt{\chi^2_{(\tau)}/\tau}+\delta/\sigma)^2$.

For the pretest corrected forecast

$$M_4 = E(b-b_4)^2 = (b-1)^2 - (b-1)^2EI_{(-\infty,c)}(u) + \sigma^2EI_{(-\infty,c)}(u)u^2, \qquad (14)$$

again using the result $I^2=I$. Application in (14) of the expressions for EI and EIu^2, given in Judge et al. (1985), and Judge and Yancey (1986), yields

$$M_4 = \begin{cases} (b-1)^2 - \tfrac{1}{2}(b-1)^2P_1 + \tfrac{1}{2}\sigma^2P_3 & \text{if } d \leq 0 \\ (b-1)^2 - \tfrac{1}{2}(b-1)^2(2-P_1) + \tfrac{1}{2}\sigma^2(2-P_3) & \text{if } d > 0 \end{cases} \qquad (15)$$

Finally, when the forecast is always corrected,

$$M_5 = E(b-b_5)^2 = E(b-b^*)^2 = \sigma^2 , \qquad (16)$$

i.e. simply the variance of the estimate of the slope coefficient.

Consider first a comparison of the M_i's of the forecasts 1, 2 and 3. Subtraction of (10) from (11) gives $M_2-M_1=2b-1$, so that $M_1 < M_2$ if $b > 1/2$, as already stated above. One interpretation of this result is that if b is large, x^f tends to underestimate x, and when b is small the forecast overestimates x. If $b < 1/2$, the overestimation is so large that it is better to use the mean E(x) as the forecast. Granger and Newbold (1986), however, warn that a large value of the slope coefficient may reflect the fact that optimally the variance of the forecast should be smaller than that of the actual values. On the other hand, a small value of b may result from inefficient forecasts, for which $Var(x^f) > Var(x)$, rather than from overestimation. From (10), (11) and (13) it can be seen that the pretest forecast f_3 dominates forecast f_1 when $b < 1/2$, and the mean forecast when $b > 1/2$, but it never dominates both of these forecasts.

Next compare forecasts 1,4 and 5. From (10), (15) and (16) it can be seen after some algebra that $M_4 < M_1$ if $\sigma^2/(b-1)^2 < P_1/P_3 < 1$ when $d \le 0$ and $\sigma^2/(b-1)^2 < (2-P_1)/(2-P_3)$ (> 1) when $d > 0$. On the other hand, $M_4 < M_5$ if $\sigma^2/(b-1)^2 > (2-P_1)/(2-P_3) > 1$ when $d \le 0$ and $\sigma^2/(b-1)^2 > P_1/P_3$ (< 1) when $d > 0$. It is therefore possible that the pretest corrected forecast for some parameter values dominates the other forecasts. The gain from using the correction after pretesting therefore depends on the deviation of the forecast from optimality, the variance of the estimated correction factor, and the critical value of the pretest.

To illustrate the relationships between the forecasts, M_i (i=1,...,5) are plotted against b in Figure 1. The figure is drawn keeping σ fixed at 0.5 and using the critical value c=-1.725, which corresponds to the 5 percent significance level in the pretest with 20 degrees of freedom. For very small values of b the mean forecast has the smallest MSE. For a fairly wide range of values of b around 1 the unrevised forecast performs best, and for large b's the corrected forecast has the lowest MSE.

=== Figure 1 here ===

Since Figure 1 is based on a fixed value of σ, it is worthwhile to consider the simultaneous effect of b and σ on M_3 and M_4. This is shown in Figures 2 and 3. The main conclusion from Figure 2 is that the performance of the pretest forecast is worst for a combination of large b and small σ. In this situation the original forecast is used since because of the small standard error the hypothesis $b \geq 1/2$ is likely to be accepted when it is true. From Figure 3 it can be seen that the MSE of the pretest corrected forecast is highest for a combination of large b and large σ. This is a situation where the true value of b is large, but the estimate b^* has such a large standard error that $b \geq 1/2$ may be rejected, although it is true. In addition, the subsequent correction is not good, since b^* can deviate much from the true, unknown b.

=== Figures 2 and 3 here ===

For the results to be of practical use, it would be important to have some guidelines on what significance level should be used in the pretest. Using statistical decision theory, one alternative would be to use such a critical value that minimizes maximum regret (see Sawa and Hiromatsu (1973)). The regret is defined as the difference between the risk of a forecast and the minimum possible risk. Here the risk is $M_i=M_i(c|b,\sigma)$, so that the regret is $r_i(c|b,\sigma)=M_i(c|b,\sigma)-\min_c M_i(c|b,\sigma)$. The optimal minimax regret critical value is hence such c' that minimizes $\max_{b,\sigma} r_i(c|b,\sigma)$.

For the pretest forecast, the regret is $M_3-\min_c M_3$, where $\min_c M_3$ is either M_1 (when $b \geq 1/2$) or M_2 (when $b < 1/2$). For the pretest corrected forecast the regret is $M_4-\min_c M_4$, where $\min_c M_4$ is either M_1, M_5 or M_4, depending on the values of b and σ. For a given value of c, the maximum regret was calculated, assuming a range of parameter values for b and σ. Then c was chosen so that a minimum of the maxima was obtained. In the case of the pretest forecast, the critical value was negative and very large in absolute value, which implies a very low significance level in the pretest. Therefore, in practice the pretest forecast does not appear to be a useful alternative, since it is optimal to use the original forecast.

In the case of the pretest corrected forecast the optimal critical values again greatly depend on what is assumed about the possible range of values b and σ can take. Critical values and corresponding significance levels for some combinations of b and σ are presented in Table 1. Increasing the possible range of b increases the optimal significance levels and increasing the possible range of σ lowers them. An explanation of this result is that when b can be large, the regret from not using a correction is high. Therefore it may actually be optimal to use such a significance level that the hypothesis $b \geq 1/2$ is sometimes rejected although it is true. When σ can be large, there may be a high regret from using a correction. Therefore it is better to use a low significance level.

=== Table 1 here ===

Casual evidence suggests that regressions of realizations on forecasts and a constant typically give values of the slope coefficient in the range (0,2) (see e.g. McNees 1978). Hence it may be realistic to assume a priori b to be so small that it is optimal to reject the hypothesis $b \geq 1/2$ seldom. Consequently, mostly the original forecast would be used.

3. Extensions

In this section several extensions to the analysis of the previous section are considered. First, the effects of autocorrelation in the error term v are analyzed. Second, the possibility of an additive bias in x^f is discussed. Finally, extensions to the case of several forecasts are studied.

Because information lags and data revisions, v in (1) may be serially correlated; in particular, v may have a moving average error process. This has implications on the testing of b. Generally, autocorrelation leaves the OLS estimate b^* unbiased, but it is inefficient. The estimated standard error σ^* is biased, but the direction of the bias can be determined only in some special cases. For positive, first order serial correlation, it may be argued that σ^* is downwards biased (see Nicholls and Pagan 1977). Therefore ignoring the error structure would tend to inflate the t-test statistic of b^*, thereby leading to the rejection of $b \geq 1/2$ too often. This would support the use of fairly high critical values in the pretest. If the error process is more complicated, no straightforward conclusions can be drawn. Another issue is whether the autocorrelation should be tested for and if detected, be taken into account in estimation. This leads to an additional pretest, whose consequences cannot be determined analytically. There is some evidence on the impact of autocorrelation pretesting on subsequent hypothesis tests on parameters, which can give some indication on the influences. King and Giles (1984) have found that when an autocorrelation pretest estimator is used in the presence of first-order autocorrelation, the actual size of a t-test on a parameter is closer to the nominal size than when OLS or autocorrelation correction without pretesting is used. However, in models like (1), autocorrelation correction may give inconsistent estimates and therefore often only the standard errors are corrected (e.g. Brown and Maital 1981). The small sample implications of using corrected standard errors after pretesting for autocorrelation are not clear.

It has been assumed above that x^f has no additive bias or it has been removed. Consider now the effect of allowing the forecast to have such a bias, denoted by m. This means that the forecast f_1 would be replaced by f_1-m. In general, forecast f_i would be replaced by $b_i(f_i\text{-m})$. As a result, MSE(f_i) would have an additional term $Eb_i^2m^2$ and hence in the comparison of the forecasts the term $Eb_i^2m^2/Var(x^f)$ should be included in M_i, which involves an upward shift in it. For M_1, the shift is uniform for fixed values of the bias and the forecast variance, and for M_2, there is no shift, since b_2=0. For M_3, M_4 and M_5 the shift is not uniform and depends additionally on b, σ and c. The analysis of these shifts would require the specification of two additional parameters, m and $Var(x^f)$. Hence the only straightforward conclusion that emerges is that the use of the mean forecast becomes more attractive compared to the other forecasts.

Consider finally an extension to the analysis of several forecasts. Typically several macroeconomic forecasts would be used in a forecasting model. Assume that one wants to forecast variable y using variables $x_1, \ldots, x_k$, for which forecasts $x_1^f, \ldots, x_k^f$ are available. y is forecasted using an equation (in deviation from the means form)

$$y - E(y) = \Sigma_{j=1}^{k} \beta_j (x_j - E(x_j)) + u \qquad (17)$$

where the β_j's are assumed to be known. The forecast of $y_T - E(y)$ is, when forecasts of the type 1 from above are used for each x_j,

$$F_1 = \Sigma_{j=1}^{k} \beta_j (x_{jT}^f - E(x_j^f)) \ . \qquad (18)$$

An alternative to this is such a forecast that for one of the x_j's, e.g. x_1, a forecast of the type 2 from above is used. That is, this variable is forecasted to be equal to its mean, so that deviation from the mean is zero, whereas for the other variables a published macroeconomic forecast is used. The resulting forecast is

$$F_2 = \Sigma_{j=2}^{k} \beta_j (x_{jT}^f - E(x_j^f)) \qquad (19)$$

which has MSE

$$MSE(F_2) = E(y_T - E(y) - \Sigma_{j=2}^{k} \beta_j (x_{jT}^f - E(x_j^f)))^2 = E(y_T - E(y) - F_1 + \beta_1 (x_{1T}^f - E(x_1^f)))^2$$

$$= MSE(F_1) + \beta_1^2 E(x_{1T}^f - E(x_1^f))^2 + 2\beta_1 E(\Sigma_{j=1}^{k} \beta_j ((x_{jT} - E(x_j)) - (x_{jT}^f - E(x_j^f))) + u_T)(x_{1T}^f - E(x_1^f))$$

$$= MSE(F_1) + 2\beta_1^2 E(x_{1T}^f - E(x_1^f))^2 (b - \frac{1}{2})$$

$$+ 2\Sigma_{j=2}^k \beta_1 \beta_j E((x_{jT} - E(x_j)) - (x_{jT}^f - E(x_j^f)))(x_{1T}^f - E(x_1^f)) \qquad (20)$$

assuming that (1) holds for x_1, and that $Eu_T(x_{1T}^f - E(x_1^f)) = 0$. Hence the decision on whether it is better to use the forecast than the **mean** of the variable depends not only on the accuracy of the forecast, i.e. on b, but also on the correlation of the forecast with the other forecasts and with the realizations of the other variables, as well as on the signs of the coefficients of the variables in the forecasting model for y. Therefore there is no easy way to determine the usefulness of a single forecast in the presence of several other forecasts.

4. Conclusions

This paper has analyzed from a pretesting point of view some suggested approaches to the analysis of forecast usefulness and forecast correction. It is sometimes suggested that end users of published forecasts could improve them either by using some naive forecasts or by correcting the forecasts by some mechanical way. The results in this paper show that when the pretesting consequences of these kinds of approaches are properly taken into account, end users would in most situations be better off using the original forecasts, or if the correction is used after a preliminary test, a fairly low significance level should be used in the test.

There are also some other arguments against forecast correction. Published forecast may have biases, but they are not likely to persist very long, since the forecasters themselves would most likely correct them. Therefore the correction factors may not be constant over time. A time-varying relationship between forecasts and realizations can also be caused by changes in the forecasting methods and models the forecasters are using. This also supports the use of fairly low significance levels in tests of forecast accuracy. In any case, macroeconomic forecasts include information of a specific economic situation. This should be carefully assessed before any mechanical correction are made. Otherwise the forecast may for example be adjusted in a wrong direction.

There are, however, cases where systematic biases may occur. If business or consumer attitude surveys are used as inputs in e.g. a company sales forecasting model, a correction may be necessary. Those answering the surveys are not likely to make an explicit evaluation of their own past forecasts and are therefore not able to correct themselves any systematic biases.

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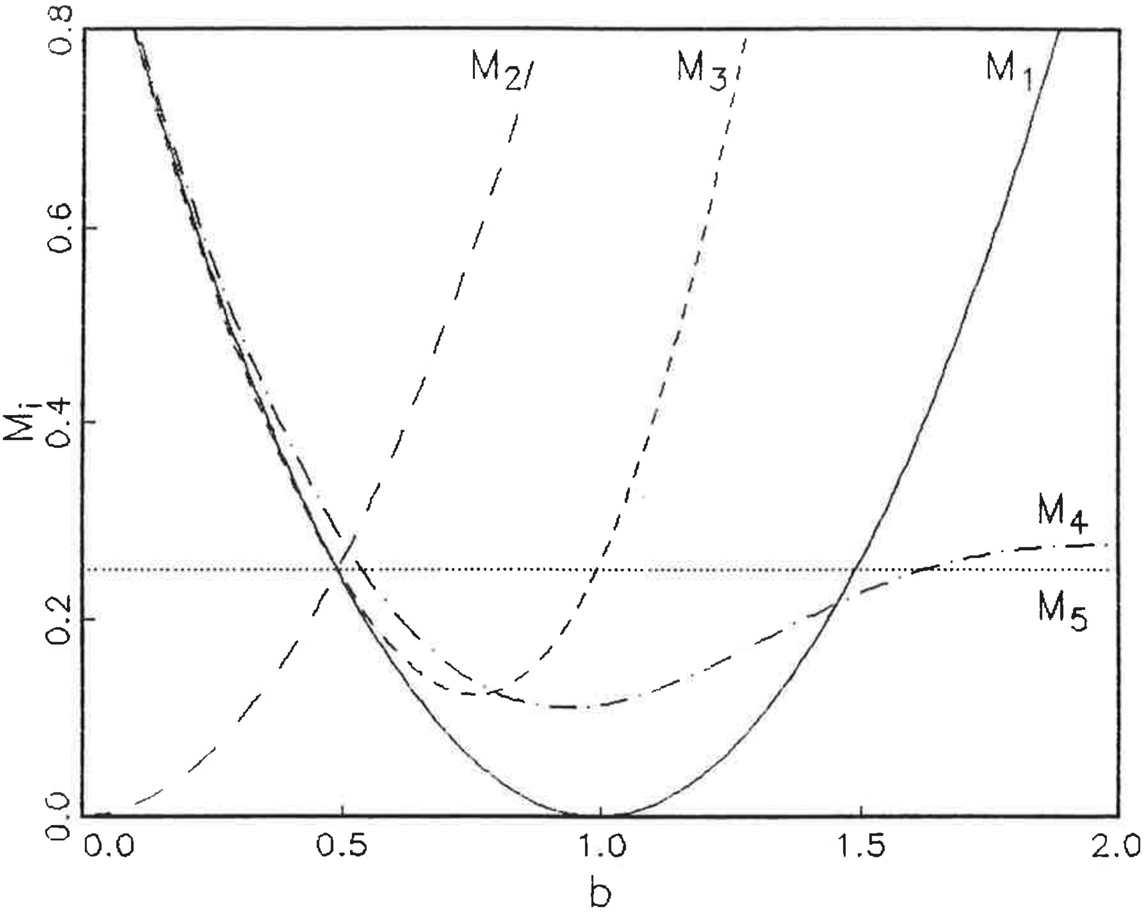

Figure 1. M_i (i=1,...,5) plotted against b; σ is fixed at 0.5 and c=-1.725 (5 percent critical value in the preliminary test with 20 degrees of freedom).

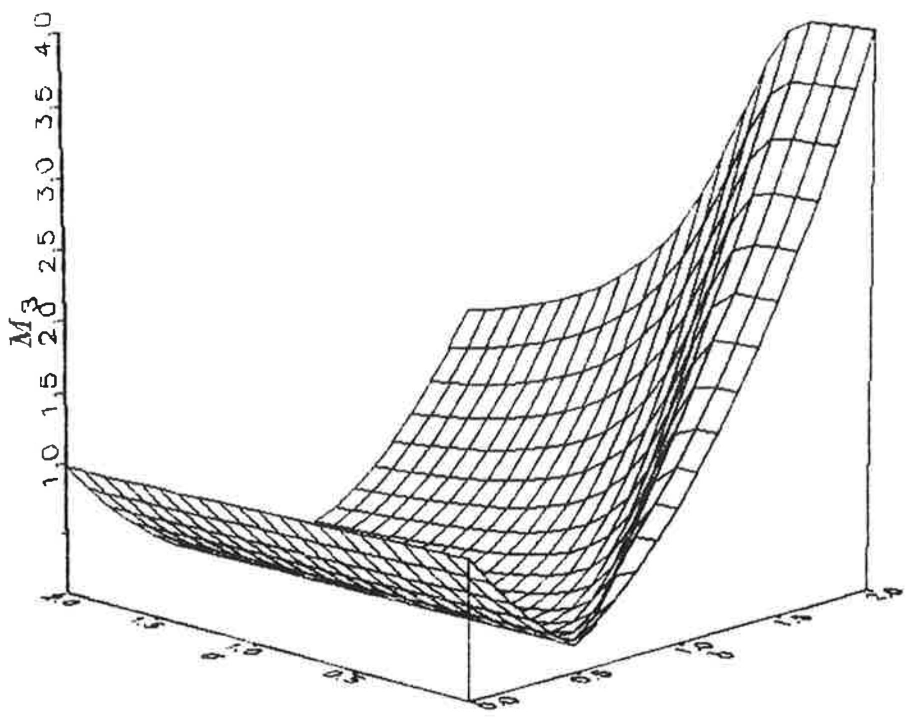

Figure 2. M_3 plotted against b and σ; c=-1.725 (5 percent critical value).

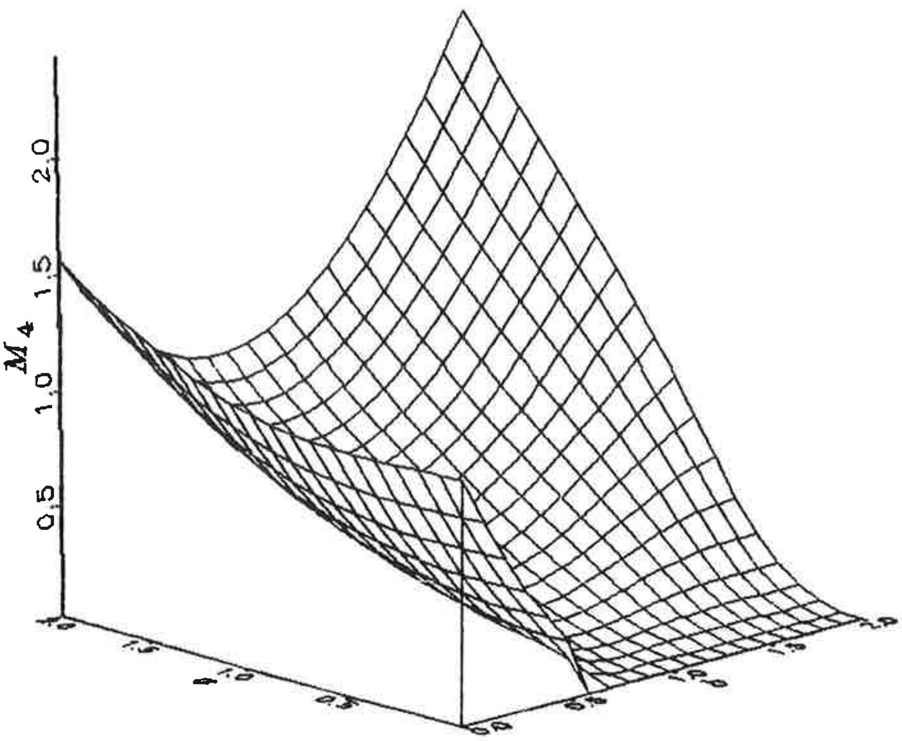

Figure 3. M_4 plotted against b and σ; c=-1.725 (5 percent critical value).

Possible range of b	Degrees of freedom (τ)	Possible range of σ (.01,5) Critical value (c)	Significance level %	(.01,10) Critical value (c)	Significance level %
(0,5)	10	-2.14	2.90	-2.95	0.73
	20	-2.11	2.38	-3.10	0.28
(0,10)	10	-1.28	11.47	-1.88	4.48
	20	-1.28	10.76	-1.86	3.88

Table 1. Optimal critical values and significance levels in the pretest for the pretest corrected forecast

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