Judgmental Adjustments of Previously Adjusted Forecasts*

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ABSTRACT

Forecasts are important components of information systems. They provide a means for
knowledge sharing and thus have significant decision-making impact. In many organi-
zations, it is quite common for forecast users to receive predictions that have previously
been adjusted by providers or other users of forecasts. Current work investigates some
of the factors that may influence the size and propensity of further adjustments on
already-adjusted forecasts. Two studies are reported that focus on the potential effects
of adjustment framing (Study 1) and the availability of explanations and/or original
forecasts alongside the adjusted forecasts (Study 2). Study 1 provides evidence that
the interval forecasts that are labeled as "adjusted" are modified less than the so-called
"original/unadjusted" predictions. Study 2 suggests that the provision of original fore-
casts and the presence of explanations accompanying the adjusted forecasts serve as
significant factors shaping the size and propensity of further modifications. Findings of
both studies highlight the importance of forecasting format and user perceptions with
critical organizational repercussions.

***Subject Areas: Decision Support Systems, Factorial Experimental Design,
Forecast Adjustments, Forecast Explanations, Judgmental Forecasting, and
Laboratory Experiments.***

INTRODUCTION

Forecasts are important mechanisms for knowledge sharing and operational de-
cision making in organizations. Effective construction and communication of

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forecasts provide a fundamental challenge for the design and management of information systems, with significant behavioral implications. Human judgment is an inseparable component of forecasting processes overall (Webby & O'Connor, 1996; Önkal-Atay, 1998; Önkal-Atay, Thomson, & Pollock, 2002; Fildes, Goodwin, & Lawrence, 2006; Lawrence, Goodwin, O'Connor, & Önkal, 2006) and is embedded in various stages from the presentation of the forecasting problem to the fine-tuning of generated forecasts. The current article is interested in the forecast users' involvement at the latter stages of this process, where the provided predictions may not be taken at face value, but subjected to adjustments. We are interested in the extent to which the presentation mode of the forecasts impacts the decision maker's acceptance or adjustment of the provided forecast. This research can be seen as a response to the call by Venkatesh (2006) for studies in supply chain technologies that "focus on the extent to which individuals use the information from the system and have confidence and trust . . . such that they base their decisions on (it)" (p. 506). An enhanced understanding of forecast users' adjustments to presented predictions may be critical for designing structured interventions to improve decision-making success in organizations (Venkatesh, Speier, & Morris, 2002). Such interventions could provide important decision support tools to managers who need to cope with a bombardment of ill-structured information and operational uncertainties (Field, Ritzman, Safizadeh, & Downing, 2006; Tiwana, Wang, Keil, & Ahluwalia, 2007).

Forecast users demand, receive, and utilize prepared forecasts in making decisions. If such forecasts are broadly consistent with the users' expectations and/or their source is trusted, they are likely to be accepted with no modification. On the other hand, large discrepancies between the forecast and the users' expectations may lead to severe adjustments. Overall, the process of judgmental review and possible adjustment represents the means whereby a user claims ownership of a forecast by incorporating his/her intuition, experience, and informational advantages (Önkal & Gönül, 2005). Research shows that forecast adjustment is a very common practice in organizations (Mathews & Diamantopoulos, 1986, 1989, 1990; Sanders & Manrodt, 1994, 2003; Fildes, Goodwin, & Lawrence, 2006; Goodwin, Lee, Fildes, Nikolopoulos, & Lawrence, 2006). Adjustments could be made to achieve different operational goals (linked to revenue management, supply chain management, logistics, quality management, etc.) and may provide effective means of reflecting recent changes in the organizational environment (Mukhopadhyay, Samaddar, & Colville, 2007). The importance of improving forecasts and forecast adjustments, as well as their decision-making consequences, is well documented in critical industries like the airline sector (Belobaba & Weatherford, 1996; Belobaba, 2002; Mukhopadhyay et al., 2007).

Judgmental adjustments need not be applied at a single stage. Forecast providers frequently modify their statistical forecasts through their judgmental manipulation of forecast parameters (Fildes, Goodwin, & Nikolopoulos, 2006; Goodwin, Fildes, Lee, Nikolopoulos, & Lawrence, 2007). Then the forecast, communicated through different units or departments and through different organizational levels, may receive one or more further adjustments (Fildes & Hastings, 1994). It is worth noting that a potential danger in such situations is that more than one adjustment may be made to the same time series for the same reason thus leading to double counting, however this issue is not directly addressed here.

Adjustments of already-adjusted forecasts or multiple adjustments on forecasts may become components of the complex forecasting processes in organizations, carrying significant repercussions for predictive performance. In this study we are interested in exploring the impact on forecast users of the knowledge that the forecast has already been adjusted. Does this knowledge make them more likely to accept the forecast as presented? In other words, are they more likely to trust a forecast they know has already been adjusted? We are aware of no studies on this topic and the current work aims to provide a start by exploring two important questions:

(i) Would the adjustment/acceptance behavior of a user be different if she thinks she is receiving an already-adjusted forecast instead of an original/unadjusted forecast?

(ii) Would providing explanations of already-adjusted forecasts make a difference in users' further modifications?

Investigating the above issues is essential in order to enhance our understanding of forecast adjustment behavior. Given that such explorations are believed to yield important ramifications for both the forecasting practice and research, the current article aims to provide a basis for future research into the adjustment processes. We report two studies that investigate the dynamics of judgmental adjustment: the first study focuses on the potential consequences of adjustment framing (Question 1), and the second study examines the effects of providing explanations alongside the adjusted forecasts (Question 2).

The organization of the article is as follows. A brief literature review on judgmental adjustment of forecasts is provided next, followed by the details of Study 1 and Study 2, along with their separate findings. Finally, the article concludes with a general discussion.

LITERATURE REVIEW AND RESEARCH HYPOTHESES

Previous work on judgmental adjustments has investigated the influence on adjustment activity of such factors as the nature of the time series, quality of the provided forecast, amount and reliability of contextual information, quality and extent of information supporting the forecast such as different types of explanations, forecast users' involvement in the forecasting process, and effort required to make an adjustment. While the majority of the studies have been laboratory based, a few have been large field studies. The presence or absence of contextual information forms a significant dividing line in this literature. In an organizational setting, forecast review, and possible adjustment, is undertaken in a rich environment of contextual information. On the other hand, most of the laboratory-based studies have been done with no contextual information in order to reduce the dimensionality of the study and to provide a baseline where both the computer model and forecast user are restricted to the same database of historical information. In this first study on the impact of adjustments, we utilize this research model and thus confine ourselves in the literature review to studies where contextual information is not available.

Forecast Adjustment Literature

In this review of research relevant to forecast adjustment without contextual information, we will examine the influence of the nature of the time series, the quality of the forecast, the influence of the involvement of the forecast user in the process, and the presence of supporting information in the form of explanations.

Nature of the Time Series

In their review of 25 years' progress in judgmental forecasting research, Lawrence et al. (2006) discussed the often contradictory nature of the findings. They frequently attributed this to the particular characteristics of the time series forecasting task(s) underlying the findings. Their review concluded that while people can be very effective forecasters, equaling the accuracy of the best techniques, their forecasts exhibit some general tendencies and biases. For example, people respond to upward trending series differently than to downward trending series, and tend to damp the slope of both up and down trends. They confuse randomness with signal, but perform better than statistical forecasting with unstable series (Lawrence et al., 2006). Focusing specifically on judgmental adjustment, Sanders (1992) reported that judgmental adjustments on statistical forecasts lead to improved point forecasting accuracy when the series had low-noise and a definite and identifiable pattern (like seasonality), but worse accuracy for high-noise series. We conclude that a study involving judgmental forecasting adjustment needs to contain a wide range of possible series shapes for its results to be considered generalizable.

Quality of the Initial Forecast

Lim and O'Connor (1995), via a laboratory experiment, demonstrated a strong human tendency to overadjust. In their experiment, graduate students in a forecasting and decision support class played the role of a marketing manager and were provided a good statistical forecast together with a screen plot of the sales history. There were no exceptional events in the time series. The subjects could either accept the statistical forecast as their final forecast or adjust it. The experiment was rolled forward period-by-period, allowing learning. The subjects received a monetary incentive on the basis of the final forecast accuracy and could view the displayed current and total incentive earned and what would have been earned had the statistical forecasts been accepted (i.e., no adjustments made). The results showed that the subjects changed a large fraction of the forecasts with a negative impact on accuracy, and so earned less than if they had made no adjustments. That is, despite the continuous display of information showing that their adjustments were reducing accuracy and costing them money, they continued to adjust the statistical forecasts. In a second experiment, the subjects were provided with an artificially excellent forecast constructed by averaging the actual with the forecast. This was to explore how subjects would respond to a forecast far superior to what could be estimated by any normal means. The results showed that although fewer forecasts were adjusted than in the previous experiment, the subjects were not able to see that the system forecast was so good that it should under no circumstances be adjusted. However, as may be expected, providing a very accurate forecast significantly improved the accuracy of the judgmentally adjusted forecasts, although

they were less accurate than the provided forecast. Interestingly, groups receiving low-reliability forecasts achieved some improvements in accuracy over the initial judgmental forecasts. Thus, we conclude that in reviewing a provided forecast for adoption or adjustment, as the forecast reliability increases, people tend to be more willing to trust it (i.e., make no adjustment to it). However, they tend to exhibit excessive confidence in their own judgment and discount the provided forecast.

Forecast User's Participation

Saffo (2007) argues that users of forecasts need to be sufficiently involved in the forecasting process to be able to make assessments of quality or acceptability based on these predictions. Lawrence, Goodwin, and Fildes (2002) used a laboratory experiment to investigate the influence of participation on acceptance of a provided forecast. High participation was operationalized by allowing the user to select the forecasting technique and parameters from a range of alternatives within the software package. Low participation relegated these selection decisions to the software but in all other ways the subjects in the two treatments faced similar tasks. The results showed that users who had participated in the development of the forecasts changed 16% of the provided forecasts, while those only slightly involved changed 37% of the provided forecasts. This clearly showed that participation led to much greater trust and satisfaction with the provided forecasts. Lawrence and Low (1993) in a large study of user satisfaction with a corporate information system showed that participation did not have to be directly experienced to increase acceptance. If a colleague participated by being consulted and involved then the outcome was trusted and accepted. This suggests that when a forecast is known to have been reviewed and adjusted, it is more likely to be accepted without modification.

Explanations

Explanations can provide powerful communication mechanisms to (i) convey the reasons behind forecasts, (ii) express the rationale behind modifications to forecasts, and (iii) emphasize that a review and adjustment has already been performed on the presented forecasts. Relatively few studies have examined explanations within the forecasting domain. One of the exceptions was provided by Goodwin and Fildes's (1999) study on special events (i.e., sales promotions), where they provided short explanations to one of the experimental groups in addition to statistical forecasts. The impact of those explanations was minimal, however, and, thus, they were only briefly mentioned.

In a more comprehensive study of the effects of explanations on forecast acceptance, Lawrence, Davies, O'Connor, and Goodwin (2001) provided the participants with technical explanations (explaining the method used to generate the forecasts) and/or managerial explanations (conveying what the forecast means in context of the time series). The results suggested a highly positive and significant effect on forecast acceptance and user confidence for both explanation types.

Manipulating the structural characteristics of explanations (i.e., explanation length and the conveyed confidence in explanation) to observe their effects on the adjustment/acceptance of provided statistical forecasts, Gönül, Önkal, and Lawrence (2006) found that long explanations conveyed with strong confidence

were more persuasive for accepting the provided forecasts. With a slightly different focus, a recent study involving explanations within a forecast generation task (Mulligan & Hastie, 2005), investigated the effects of sentence ordering in explanations. Results showed that the story order has a direct effect. Although adjustments were not of interest in this study, the findings suggest the important role explanations can play in influencing user perceptions in a forecasting task.

Advice Literature

Forecast review and adjustment can be thought of as a special case of advice taking and decision making. Over the last decade, considerable research has been undertaken in this field using a variety of research tasks and research settings principally using human as compared to computer-mediated advice. Bonaccio and Dalal (2006) in a major review concluded "one of the most robust findings in the literature is that . . . judges did not follow their advisors' recommendations nearly as much as they should have (to truly have benefited from them)" (p. 129). But expert advice was heeded more than novice advice suggesting perceptions of the reliability of the advisor was an important element. We note that these findings are broadly consistent with those reported for forecast adjustment and suggest that as already-adjusted forecasts are likely to be seen as more reliable than unadjusted forecasts they are more likely to be heeded and accepted without adjustment. Additionally, Yaniv (2004) suggests this discounting of the advice occurs because the decision maker can more easily understand the reasons and evidence for his/her opinion relative to the advisor's. Thus, forecast adjustments accompanied with an explanation should allow the decision maker to understand the basis of the advice and more readily accept it.

Relatedly, Sussman and Siegal (2003) investigated the influence and adoption of advice mediated by email. They found that perceptions of argument quality and credibility contributed to the message being viewed as useful, and that advice perceived as useful was associated with adoption. Waern and Ramberg (1996), investigating people's perception of computer and human advice, found trust in computers was less than for humans, with knowledge in the specific task environment being an important factor influencing trust of the computer advice. As participation leads to knowledge, this is consistent with Lawrence et al. (2002).

Research Hypotheses

Review of the experimental and empirical evidence suggests that when a statistical forecast is provided, it is generally discounted and excessive adjustment takes place (Lawrence et al., 2006). No research has yet investigated peoples' reactions to an already-adjusted forecast compared to an original unreviewed forecast. However, as the forecast user's likelihood of accepting a provided forecast is positively influenced by its perceived reliability (Lim & O'Connor, 1995; Bonaccio & Dalal, 2006), we hypothesize that an already-adjusted forecast is more likely to be accepted without further adjustment than an original forecast. An important link here is that when the adjustment has been carried out by an expert, the perception of the reliability of the forecast should be enhanced. Furthermore, since the review and adjustment process implies involvement, we anticipate that an

already-adjusted forecast is likely to be more readily accepted than an unreviewed forecast (Lawrence & Low, 1993; Lawrence et al., 2002). A further reason in support of this hypothesis is that people exhibit greater trust of people compared to computers (Waern & Ramberg, 1996), and hence are more likely to trust an adjusted forecast compared to a raw computer-prepared forecast. Thus we hypothesize:

> *H1: Forecasts known to have already been adjusted will be less likely to be further adjusted when compared to original/unadjusted forecasts.*

Although explanations do not normally accompany forecasts or forecast adjustments, the literature surveyed suggests that their presence should significantly increase a forecast user's trust in the provided adjusted forecast both for the information contained in the explanation (Lawrence et al., 2001; Yaniv, 2004; Gönül et al., 2006) and also by increasing the salience of the adjustment. Thus we hypothesize:

> *H2: Forecasts known to have already been adjusted and accompanied with an explanation will be less likely to be further adjusted when compared to original/unadjusted forecasts with or without an explanation.*

In testing these hypotheses via the following two studies, we will operationalize likelihood of adjustment through measures that focus on the frequency as well as the magnitude of performed modifications so as to reveal a more detailed portrayal of the adjustment processes taking place.

STUDY 1: EFFECTS OF ADJUSTMENT FRAMING ON FURTHER ADJUSTMENTS

The first study aimed to explore hypothesis H1, whether there are any adjustment differences in situations where the provided forecasts are described as original/unadjusted predictions as opposed to the cases where the given forecasts are described as already-adjusted predictions.

Participants

A total of 86 second- and third-year business students from Bilkent University participated in the study. Students were randomly distributed to two groups receiving the same set of time series and forecasts. They were instructed that these were stock price series with undisclosed stock names and unrevealed time periods. Participants in Group 1 were told that they were presented with original/unadjusted forecasts prepared by "state of the art" forecasting software. The subjects in Group 2 were given the same time series and set of forecasts as Group 1 but the forecasts were described as having been reviewed and adjusted by an expert in the field. No other information about how the original forecasts were generated or how they were adjusted was given to the participants.

Experimental Design

A program called the "Experimental Forecasting Support System" (EFSS) was specifically written for this study. This program presented each participant with a

total of 18 weekly time series and an associated one-period-ahead point forecast and 95% predictions intervals. This article adopts the same generated-series approach used in other studies assessing the degree of adjustment activity (e.g., Lawrence et al., 2002; Gönül et al., 2006). Three levels of trend (increasing, decreasing, and no trend) and two levels of variability (low and high noise) were used to generate six different patterns of time series. With three samples from each pattern, 18 series were constructed in total.

The time series formula used was:

$$x(t) = 3500 + bt + error, \tag{1}$$

where b takes the value –70, 0 or 70 for decreasing, no trend, and increasing trend and the error is normally distributed with zero mean and standard deviation of either 5% (.05 × 3,500) or 15% (.15 × 3,500). The base value of 3,500, the slope value of 70 (computed via trend analyses of the realized stock index values) and the standard deviation values were set to make the constructed series resemble typical stock series on the Istanbul Stock Exchange. One instance of each of the 18 time series were constructed, with the same set of 18 time series given to each subject.

One-period-ahead point forecasts were constructed by Holt's exponential smoothing method with error-minimizing parameters. Given the simple stable generating function used for the time series, we would anticipate that the forecasts from Holt's method would be hard to beat. Based on the error variance of the point estimates, 95% interval forecasts were obtained. These predictions were presented to the participants as either "original/unadjusted" or "adjusted" forecasts depending on their group.

The procedure for the two experimental groups was as follows:

Group 1: "Original/unadjusted forecast" framing

Subjects were instructed to "click below to view the unadjusted/original forecasts" after being presented with a time series plot of weeks 1 to 25 of an individual "stock price." Upon clicking on the indicated box, the forecast developed by Holt's method appeared on the graph for period 26, the next period on the graph. Participants were then requested to review the forecast for week 26 and to modify it if they did not wish to accept the provided forecast. They could easily revise the point and intervals formats by indicating their predicted values on the graph with the mouse and clicking on their modified values. If they did not click on any one of the formats, the forecasts remained unmodified. They could then move on to the next series by clicking on the "continue" button (see Figure 1 for a sample screen shot). The program terminated when the entire 18 series were completed. All the values were saved to the diskette that each student worked on. A total of 43 subjects completed the task in Group 1.

Group 2: "Adjusted forecast" framing

Participants were instructed that "adjustments have been made to the forecasts— click below to view the adjusted forecasts" following the presentation of the time series plot of 25 weeks of the "stock price." Upon clicking on the indicated box, a forecast for week 26 appeared on the graph. This was the same forecast as provided to the Group 1 subjects and called "unadjusted/original forecast." The rest of the

Figure 1: A screenshot from EFSS—Group 1, Study 1.
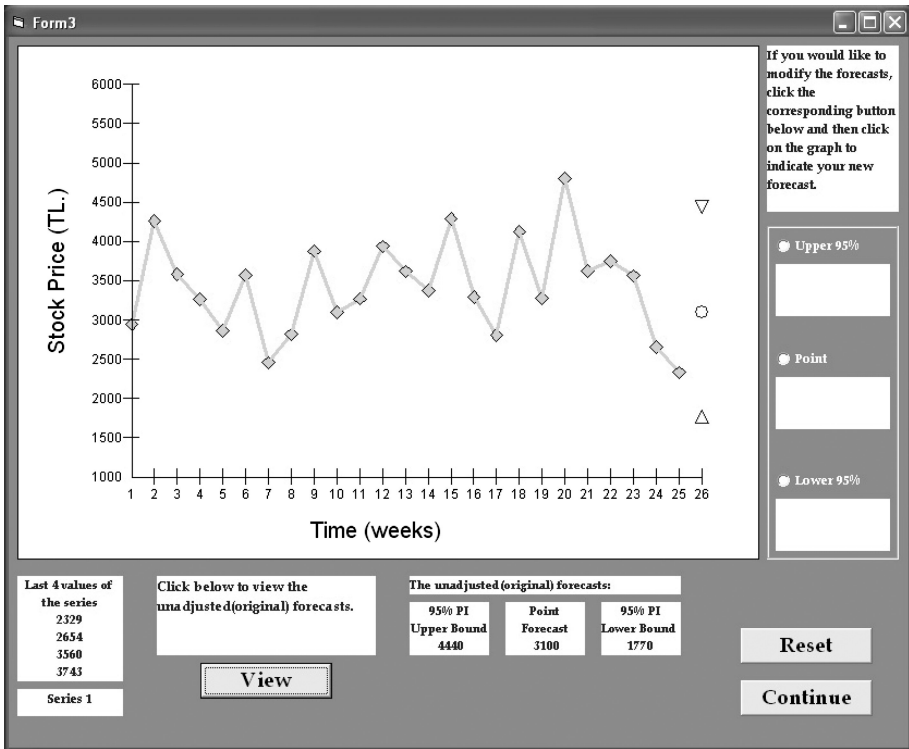
procedure was the same as in Group 1 with the program terminating upon the completion of 18 series (see Figure 2 for a sample screen shot). A total of 43 subjects completed the task in Group 2.

To serve both as manipulation checks to investigate whether the task items were perceived as intended as well as to explore detailed reasons for presence/absence of forecast modifications, exit interviews were conducted with each subject upon completion of their task. As noted in Bachrach and Bendoly (2006), such interviews provide subjective measures of convergent validity. In our study, they took the form of face-to-face interviews where the students were asked questions on

(i) their understanding and perception of the presented task,

(ii) clarity/ambiguity of the instructions and task,

(iii) their most important reason for *not modifying* a given forecast,

(iv) their most important reason for *modifying* a given forecast, and

(iv) *Group 1 subjects:* if they modified the provided forecast, why and how would they expect their modifications to differ if they were to receive *adjusted forecasts*

Figure 2: A screenshot from EFSS—Group 2, Study 1.
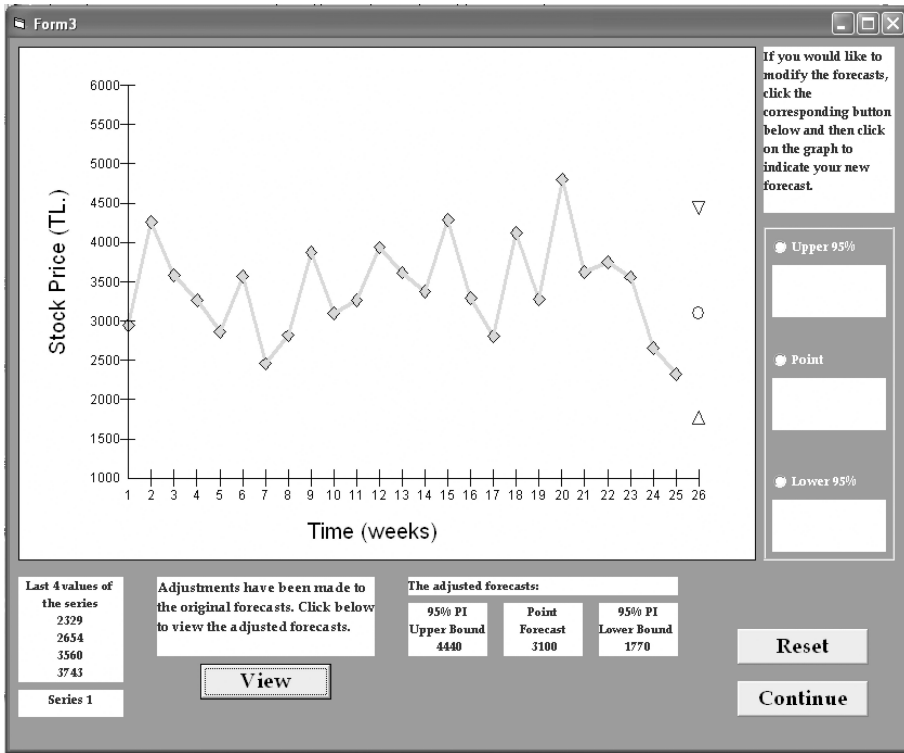
(v) *Group 2 subjects:* if they modified the provided forecast, why and how would they expect their modifications to differ if they were to receive *unadjusted/original forecasts*.

Analysis Methodology

The key measure for testing both H1 and H2 is the fraction of forecasts adjusted—the percentage of forecasts adjusted is a measure of the likelihood of adjustment. However, the frequency of forecast modifications may not reveal the complete picture of the adjustment processes. For example, there may be the same fraction of adjustments for both groups but if the adjustments are smaller for one group this may indicate a greater satisfaction with their forecasts but still a desire to tinker with the given values. Or, there may be situations where very few forecasts are modified; however, the size of these modifications is quite large. This may be viewed as a signal of special insight/information about those particular cases. Hence, the size of performed modifications may reveal information complementing the adjustment frequency, thus contributing to our understanding of the adjustment processes. Finally, forecast accuracy is computed as a supplementary measure to address performance implications. Table 1 depicts the three measures used under each of these categories for both the point and interval forecasts.

Table 1: Performance measures.

	Frequency of Adjustments	Size of Adjustment	Accuracy
Point Forecasts	% of Point Forecasts Adjusted	APAP (Absolute % Adjustment in Point Forecasts)	MAPE
Interval Forecasts	% of Interval Forecasts Adjusted	APAI (Absolute % Adjustment in Interval Forecasts)	Hit Rate

Frequency of Adjustments

The percentages of point and interval forecasts that were modified were used. An adjustment on any of the bounds for a particular interval forecast was counted as a single adjustment for that interval. That is, a prediction interval was considered adjusted if at least one of its bounds was modified.

Size of Adjustment

To capture the size of adjustments, absolute percentage adjustment in point forecasts (APAP) was used for point forecasts, while the absolute percentage adjustment in interval width (APAI) score was utilized for the interval forecasts. These performance measures were calculated as defined below:

$$APAP = \frac{|adjusted\ point\ forecast - provided\ point\ forecast|}{provided\ point\ forecast} \times 100. \quad (2)$$

$$APAI = \frac{|adjusted\ width - provided\ width|}{provided\ width} \times 100. \quad (3)$$

If no adjustments were made to the provided forecasts, these ratios automatically received the lowest possible score (0%). The further away the adjusted predictions were from the provided values, the higher were the APAP and APAI scores. The means of the above measures are calculated over the adjusted forecasts only (i.e., the nonadjusted forecasts are not included in these computations).

Accuracy

Taking the expected value for the 26th week as the actual value, accuracy of the adjusted forecasts was calculated using the mean absolute percentage error (MAPE) for the subjects' point forecasts, while the "hit rate" (i.e., percentage of occasions when the actual value is contained in the interval) was used for interval forecasting performance.

Results

Exit interviews indicated that all the participants correctly perceived the labeling of forecasts in their individual groups—that is, they were totally clear about whether

the predictions given to them were "unadjusted/original" forecasts (for Group 1) or were "adjusted" forecasts (Group 2). However, the students receiving so-called "adjusted" forecasts indicated that the lack of any information on the previous adjustment (e.g., what the original forecast value was, how much of an adjustment was made, what were the reasons, etc.) led to a "vagueness/incompleteness/fuzziness" about the presented forecast values and that their modifications could have been different if they were given that information. The stated *most important* reasons for modifying or not modifying a forecast were quite similar in two groups (i.e., "whether the forecasts were similar to what they expected/whether they made sense or not" given the time series information). Group 1 participants mostly indicated they would have modified less had they received adjusted forecasts because these values would have been "already worked on." Group 2 subjects said they probably would have modified more had they received unadjusted forecasts, since the fact that someone else had already worked on these predictions made a difference for them, even though they did not know of the details of the adjustment.

Point forecasts

Table 2 presents the results of the two groups across the relevant performance measures for point predictions. No significant differences could be found between the two groups in terms of the frequency of adjustments and the accuracy (i.e., MAPE) of adjusted point forecasts. However, when adjustments are made, the size of adjustment differs between the two groups with the participants in the "adjusted" framing group making slightly larger adjustments to their point predictions ($t_{1114} = 2.00$; $p = .046$). Overall, we conclude that for point forecasts hypothesis H1 is not supported (i.e., there appears to be no differences in frequency of adjustments for point forecasts known to have or not have been adjusted).

Interval forecasts

Table 3 summarizes the results of the two groups across the pertinent performance measures for interval forecasts. There appears a significant difference in the adjustment behavior of the interval forecasts as a result of adjustment framing. Participants who believed they were receiving already-adjusted forecasts have made fewer modifications in their interval predictions (thus weakly supporting H1, as

Table 2: Overall results for point forecasts.

	Frequency of Adjustment for Point Forecasts	APAP	MAPE
"Original/Unadjusted" Framing	73.26% (774)	6.66% (567)	10.92% (774)
"Adjusted" Framing	71.96% (774)	7.55% (557)	10.27% (774)
	n.s.	$t_{(1114)} = -2.00$ $p = .046$	n.s.

Notes: Numbers in parentheses are the numbers of data points in that category.

Table 3: Overall results for interval forecasts.

	Frequency of Adjustment for Interval Forecasts	APAI	Hit Rate
"Original/Unadjusted" Framing	83.72% (774)	24.26% (646)	93.54% (774)
"Adjusted" Framing	79.33% (774)	21.96% (609)	93.41% (774)
	$t_{(1532)} = 2.23$ $p = .026$	n.s.	n.s.

Notes: Numbers in parentheses are the numbers of data points in that category.

the effect size is quite small). However, once the adjustments were introduced, the magnitude of the modifications (i.e., APAI scores) was not statistically different between the two groups. The hit rates between the two groups were also very similar.

STUDY 2: EFFECTS OF PROVIDING EXPLANATIONS ALONG WITH ORIGINAL AND/OR ADJUSTED FORECASTS

In summary, Study 1 revealed very little difference between the two treatments. One possible interpretation of this result is that although the subjects were told the forecasts in the treatment condition of Study 1 were adjusted, the lack of detailed information about this prior adjustment may have led to the significance of this statement not being fully appreciated. As indicated in the exit interviews of Study 1, more information regarding the previous adjustment may enable the subjects to fully appreciate that a prior modification has already been made, as well as the extent of that modification. Study 2, designed to examine the effects of including the original forecasts and the explanations accompanying the prior adjustments, addressed this issue; the inclusion of the original forecast and the presence of explanations increases the salience of the adjustment manipulation.

The design was a 2 × 2 study with initial forecast (present and not present) and explanations (present and not present). This design enabled a further investigation of H1 as well as investigating H2. Providing explanations for prior adjustments on forecasts may be effective in communicating the reasons and the rationale behind the previous modifications, thus further increasing the salience of the adjustment and persuading the users of the logic for the adjustments. Presenting an explanation for the adjustment may lead to an improvement in the acceptance of an already-adjusted forecast, as signaled via smaller and fewer further modifications. Alternatively, the forecast users may want to "make their mark" or demonstrate their informational edge regardless of whether an explanation has been provided about a prior adjustment, leading to modifications independent of whether the external predictions they are given have already been worked on or not.

Participants and Design

A total of 128 second- and third-year business students from Bilkent University participated in Study 2. Participants were exposed to the same set of 18 time

series employed in the first study; but used a specially modified version of EFSS (Experimental Forecasting Support System used in Study 1).

Focusing on the two factors discussed above, a 2×2 ([explanations given vs. not given] $\times$ [original forecasts given vs. not given]) factorial design was used, leading to the following four groups:

Group 1: Adjusted forecast only (explanations not given, original forecasts not given). This group is the same as Group 2 of Study 1: they received only the adjusted forecasts with no explanation or original forecast. Subjects were instructed that "adjustments have been made to the forecasts—click below to view the adjusted forecasts" after observing the time series plot of a "stock price." Upon clicking on the indicated box, adjusted forecasts appeared on the graph. Participants were then requested to give their modifications, if any. They could easily revise the point and intervals forecasts by indicating their predicted values on the graph. The program terminated when the entire 18 series were completed and all the values were saved to the diskette that each student worked on. There were a total of 31 subjects in Group 1.

Group 2: Original + adjusted forecast (explanations not given, original forecasts given). This group received the unadjusted/original forecasts in addition to the adjusted forecasts. The procedure was similar to that of the first group, with the addition that the participants were asked to click on a box to reveal the unadjusted/original forecasts prior to clicking on the adjusted forecasts box. Clicking on each of the boxes was required to proceed in the program. Also, both sets of original and adjusted forecasts were shown on the time series as they were revealed in the boxes below the corresponding plots. A total of 30 subjects participated in Group 2.

Group 3: Explanation + adjusted forecast (explanations given, original forecasts not given). This group received explanations in addition to the adjusted forecasts, but did not receive the original predictions. The procedure was a repetition of that in Group 1, with the extension that explanations for each adjustment appeared on the screen simultaneously with the adjusted forecasts presented to the subjects. Thirty-two subjects were in Group 3.

Group 4: Explanation + original + adjusted forecast (explanations given, original forecasts given). This group was provided with both the explanations and the unadjusted/original forecasts in addition to the adjusted forecasts. The procedure was a repetition of that in Group 2, with the addition of explanations for each adjustment appearing on the screen simultaneously with the adjusted forecasts. Figure 3 presents a screenshot of the program for Group 4; there were 35 subjects in this group.

As in Study 1, exit interviews were conducted with each subject where they were asked questions on

   (i) their understanding of the task,
  (ii) clarity/ambiguity of the instructions and task,
 (iii) their most important reason for *not modifying* a given forecast,
 (iv) their most important reason for *modifying* a given forecast,

Figure 3: A screenshot from extended EFSS—Group 4, Study 2.
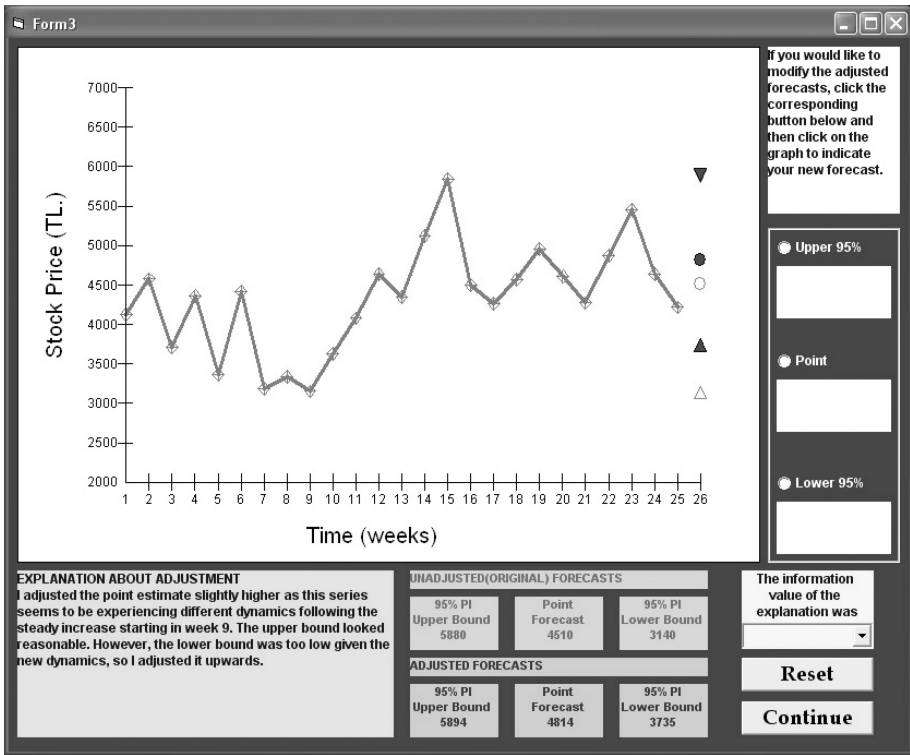
(iv) *Group 1 and Group 3 subjects:* if they modified the provided forecast, why and how would they expect their modifications to differ if they were to receive *unadjusted/original forecasts in addition to the adjusted forecasts*; *Group 2 and Group 4 subjects:* if they modified the provided forecast, why and how would they expect their modifications to differ if *they were given only the adjusted forecasts*, that is, if *unadjusted/original forecasts were not provided*; *Group 2 and Group 4 subjects:* if receiving unadjusted/original forecasts in addition to the adjusted forecasts has helped them in making modifications, how and why; *Group 1 and Group 2 subjects:* why and how would they expect explanations to be helpful in modifying given forecasts; and *Group 3* and *Group 4* subjects: if receiving explanations has helped them in making modifications, how and why.

The original/unadjusted forecasts used in Study 2 were identical to the predictions used in Study 1. The set of adjusted forecasts and the accompanying explanations were provided by an expert on stock price forecasting. This expert worked on a different version of EFSS that was tailored to display the plot of each stock price and the forecast. She was asked to review each stock forecast, make any adjustment she felt was needed and record the associated explanation. The expert's modified predictions constituted the adjusted forecasts given to the four groups in

Study 2. Analysis of the expert's adjusted forecasts revealed they are slightly less accurate (though not statistically significant i.e., $p > .10$ for both point and interval forecast accuracy) than the original forecast. This is to be expected given that the stable generating function used for the time series reflects the underlying assumptions of the statistical forecasting routine but not an expert's expectation for a stock price series. The accuracy of either the statistical forecast or the adjusted forecast is not anticipated to be a relevant feature as we are interested in the framing of the forecast and not its actual accuracy which, in any event, a subject would not be in a position to assess.

Results

Exit interviews indicated that the subjects in each group were totally clear about their individual tasks and that their *most important* reasons for modifying or not modifying the forecasts were similar to those stated in Study 1. Participants not given original forecasts indicated they expected their modifications would have been different had they seen the original predictions as they would have had more information. Along similar lines, subjects given original forecasts expected they would not have performed as well without this information as they would have been "deprived of a basis for comparing the given adjusted values." Original predictions were valued in that they "provided a basis/starting point" that "gave added information" and "supplemented the adjusted forecasts." Participants not receiving the explanations believed that explanations would be ways of "knowing the reasons behind the forecasts," stating they would have clearly preferred to have them. All the subjects who were given explanations said these have helped by acting as "guides to their modifications," enabling them to "understand the reasons and rationale behind the given adjusted values."

The same analysis methodology was used as in Study 1, focusing on the frequency of adjustments, the size of adjustments, and the accuracy of the adjusted forecasts. The same set of performance measures was utilized.

Point forecasts

Table 4 presents the results of the four groups across the relevant performance measures for point forecasts. This shows significant differences in the frequency

Table 4: Overall results for point forecasts.

	Frequency of Adjustment for Point Forecasts	APAP	MAPE
Adjusted Frcst Only	77.06% (558)	7.41% (430)	12.18% (558)
Original + Adjusted Frcst	77.22% (540)	6.13% (417)	10.62% (540)
Explanation + Adjusted Frcst	52.26% (576)	7.17% (301)	11.14% (576)
Explanation + Original + Adjusted Frcst	57.14% (630)	7.11% (360)	10.68% (630)
	$F_{3,2300} = 45.82$	$F_{3,1504} = 2.83$	n.s.
	$p < .001$	$p = .037$	

Notes: Numbers in parentheses are the numbers of data points in that category.

and size of adjustments (i.e., percentage of point forecasts adjusted and APAP scores). When an explanation accompanies the adjusted forecasts (Groups 3 and 4) there is a significantly greater acceptance of it both statistically and in effect size.

Analysis of adjustment frequency for point forecasts reveals a significant main effect for the presence of explanations ($F_{1,2300} = 135.27$, $p < .001$), with no significant main effect for the presence of original forecasts and no significant interaction effect for the presence of explanations and presence of original predictions. Given that an adjustment is made, the actual size of adjustment (*i.e.,* APAP) appears to differ among the four groups ($F_{3,1504} = 2.83$, $p = .037$). This difference seems to stem from the relatively smaller adjustments done by the second group (who received the original and the adjusted forecasts, but did not receive explanations), leading to a marginally significant main effect for the presence of original forecasts ($F_{1,1504} = 3.57$, $p = .059$). No significant differences could be found between the four groups in the accuracy of the adjusted point forecasts (i.e., MAPE). Thus we conclude for point forecasts that H2 is supported. However, increasing the salience of the forecast adjustment has not increased support for H1: the fraction of forecasts adjusted for Groups 1 and 2 (77% for the point forecasts) does not significantly differ from the fraction adjusted in Study 1 (72–73%).

Interval forecasts

Table 5 provides an overview of the findings for interval forecasts, which are broadly in line with those already observed for point forecasts. The percentage of interval forecasts adjusted and the size of adjustments are significantly different among the four groups, with no corresponding differences in hit rates.

Analysis on percentage of intervals adjusted suggests that the differences may arise from the statistically significant main effects of the presence of explanations ($F_{1,2300} = 133.42$, $p < .001$), as well as the presence of original forecasts ($F_{1,2300} = 4.93$, $p = .026$). Analysis on APAI scores also indicates that the differences in size of adjustments may be due to the significant main effects of providing explanations ($F_{1,1747} = 6.04$, $p = .014$) and providing original forecasts ($F_{1,1747} = 43.00$, $p < .001$). In addition, a significant interaction effect between these two factors appears to exist ($F_{1,1747} = 5.03$, $p = .025$). As also shown in Figure 4, when the original/unadjusted forecasts are present, further modifications are smaller in

Table 5: Overall results for interval forecasts.

	Frequency of Adjustment for Interval Forecasts	APAI	Hit Rate
Adjusted Frcst Only	88.35% (558)	27.26% (493)	85.66% (558)
Original + Adjusted Frcst	85.19% (540)	17.44% (458)	92.78% (540)
Explanation + Adjusted Frcst	69.10% (576)	22.01% (397)	89.58% (576)
Explanation + Original + Adjusted Frcst	64.60% (630)	17.20% (403)	94.76% (630)
	$F_{3,2300} = 46.81$ $p < .001$	$F_{3,1747} = 19.29$ $p < .001$	$F_{3,2300} = 11.14$ $p < .001$

Notes: Numbers in parentheses are the numbers of data points in that category.

Figure 4: Interaction effect for the *presence of explanations* and the *presence of original forecasts* on APAI scores.
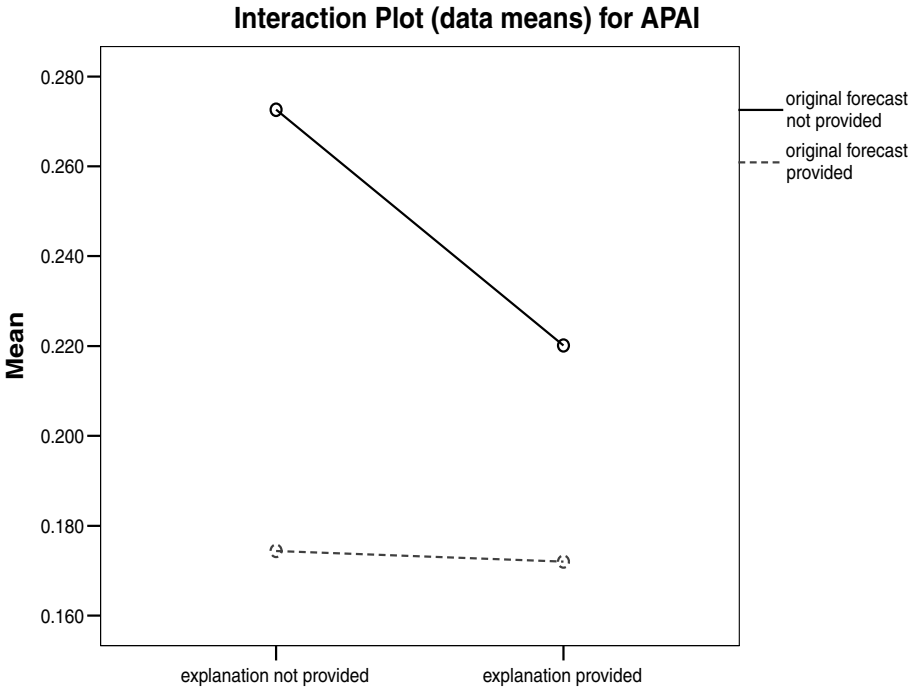
size. Similarly, when explanations are present, the participants show a tendency to reduce the size of their further adjustments. Significant interaction reveals a particular synergy that is created when both the explanations and the original forecasts are given simultaneously. In this case, the reduction in the size of adjustments is still evident, although not as pronounced as the case when either the explanations or the original forecasts are given in isolation. Thus we conclude for interval forecasts that hypothesis H2 is supported while H1 does not appear to have much support.

Additionally, these distinctions in the adjustments seem to be supported by the presence of significant differences in hit rates among the four groups ($F_{3,2300} = 11.14, p < .001$). Paralleling the findings on the percentage and size of adjustments, the interval forecast accuracies are found to be affected (i.e., improved) by statistically significant main effects of the presence of explanations ($F_{1,2300} = 6.97, p = .014$), as well as the presence of original forecasts ($F_{1,2300} = 26.29, p < .001$).

Further insight into the modifications to interval forecasts may be gleaned from Table 6. Results show that the groups not receiving the original forecasts changed the given intervals such that 48% of the modified intervals were made narrower. In contrast, only 39% of the modified intervals were reduced in interval width for groups that were given the original forecasts. Similarly, when explanations are not given, 52% of the intervals are narrowed, in comparison to 36% of the intervals when explanations are provided. These findings may be viewed

Table 6: Percentage of intervals widened/narrowed/not changed in interval width.

| | Percentage of Intervals | | | |
	Widened	Narrowed	No change in Interval Width	Total
(a) For Groups Presented vs. Not Presented the Original Forecasts (Total Number of Intervals in Parentheses).				
No Original Forecasts Presented [Groups 1 & 3]	30.33% (344)	48.15% (546)	21.52% (244)	100% (1,134)
Original Forecasts Presented [Groups 2 & 4]	34.53% (404)	39.05% (457)	26.41% (309)	100% (1,170)
	$z = -2.15$ $p = .031$	$z = 4.42$ $p < .001$	$z = -2.76$ $p = .006$	
(b) For Groups Presented vs. Not Presented With the Explanations (Total Number of Intervals in Parentheses).				
No Explanations Presented [Groups 1 & 2]	34.43% (378)	52.18% (573)	13.39% (147)	100% (1,098)
Explanations Presented [Groups 3 & 4]	30.68% (370)	35.65% (430)	33.67% (406)	100% (1,206)
	n.s.	$z = 8.09$ $p < .001$	$z = -11.89$ $p < .001$	

For groups presented versus not presented the original forecasts.
Total number of intervals in parentheses.

as suggesting that when either no original forecasts or no explanations are given to the users, their lack of information (regarding the original forecasts or explanations) translates to an unwarranted confidence, leading to tighter intervals and lower accuracy in their modified prediction intervals compared to estimates with this information available.

Perceived information value of explanations

Participants in groups supplied with explanations about previous adjustments (Groups 3 and 4) were also asked to rate the perceived information value for each of the provided explanations by selecting one of three categories ("1 = misleading," "2 = no real value," or "3 = helpful"). It was found that the mean information value rating for the group receiving only the explanations (but no original forecasts) was 2.44, while the mean rating for the group receiving both the explanations and the original forecasts was 2.47. Both of these mean ratings are significantly greater than 2, which corresponds to "no real value" ($t_{575} = 14.02$, $p < .001$, and $t_{629} = 15.75$, $p < .001$, respectively), indicating that the participants found the explanations somewhat helpful. Table 7 presents the adjustment and accuracy measures that are grouped with respect to the reported perceived information value ratings.

Table 7: Differences in adjustment and accuracy measures with respect to perceived information value.

	Misleading	No Real Value	Helpful	F	p
Group Receiving Adjusted Forecasts and Explanations for Adjustment (No Original Forecasts).					
% of Point Forecasts Adjusted	70.21%	71.43%	40.11%	$F_{2,573} = 28.65$	<.001
% of Interval Forecasts Adjusted	86.17%	85.71%	58.17%	$F_{2,573} = 26.97$	<.001
APAP	9.81%	8.76%	4.85%	$F_{2,298} = 25.07$	<.001
APAI	27.02%	22.53%	19.71%	$F_{2,394} = 3.50$	.031
MAPE	13.68%	13.64%	9.50%	$F_{2,573} = 5.60$	.004
Hit Rate	81.91%	91.73%	90.83%	$F_{2,573} = 3.61$	.028
Group Receiving Original Forecasts, Adjusted Forecasts, and Explanations for Adjustment.					
% of Point Forecasts Adjusted	81.82%	71.11%	46.21%	$F_{2,627} = 29.80$	<.001
% of Interval Forecasts Adjusted	89.90%	77.88%	53.79%	$F_{2,627} = 31.91$	<.001
APAP	10.17%	7.38%	5.61%	$F_{2,357} = 19.85$	<.001
APAI	20.91%	18.64%	14.94%	$F_{2,400} = 7.06$	.001
MAPE	17.50%	11.64%	8.65%	$F_{2,627} = 17.33$	<.001
Hit Rate	91.92%	97.78%	94.44%	n.s.	

As shown in Table 7, perceived information values of explanations are highly related with the subsequent adjustments performed on them. For both groups, when the explanations are perceived to be helpful, the frequency and size of adjustments in both point and interval forecasts decrease significantly (as shown via the percentage of point and interval forecasts adjusted, APAP, and APAI). Furthermore, regardless of whether original forecasts are or are not provided, a significant improvement in point forecasting accuracy (as indexed via MAPE) is evident with increasing perceived informativeness. For interval forecasts, when original forecasts are not given, accuracy is worse only when explanations are perceived to be misleading. On the other hand, when original forecasts are given, equally high hit rates are attained regardless of the perceived information value of the explanations.

Overall, it may be argued that as the users find the provided explanations more helpful, their trust improves in the already-adjusted forecasts leading to a higher rate of acceptance. This acceptance brings smaller and less frequent adjustments to both the point and interval forecasts. These results support the findings of Sussman and Siegal (2003) that perceptions of helpfulness are critical for adoption of advice.

GENERAL DISCUSSION

As important mechanisms for knowledge sharing, forecasts carry significant consequences for information management and organizational decision making. In many organizations, it is very common for forecast users to receive predictions that have previously been adjusted by providers or other users of forecasts. This research has investigated some of the factors that may influence the size and propensity of further

adjustments on already-adjusted forecasts. Two studies are reported: Study 1 focuses on the potential effects of adjustment framing, and Study 2 on the availability of explanations and/or original forecasts alongside the adjusted forecasts.

Overall, the findings suggest that the effects may be contingent on the forecast format, hence confirming earlier results on disparities in user perceptions of predictive formats (Yates, Price, Lee, & Ramirez, 1996; Önkal & Bolger, 2004). For point forecasts, whether the user received an original or adjusted forecast did not make a significant difference to further adjustment activity. However, in case of interval forecasts, users told they were provided with already-adjusted predictions tended to introduce slightly fewer adjustments (in comparison to users who think they are given unmodified/original predictions). Our exit interviews with the participants confirmed that forecast users appeared to show some reluctance to introduce further modifications on a forecast that is already worked on and thought about. Also, participants given original predictions indicated that they would adjust less if they were to receive already-adjusted forecasts instead of the original predictions. As might be expected, reverse comments were made by those who were led to believe that they were given already-adjusted forecasts—that is, they indicated they would introduce more adjustments if they received predictions that were not worked on. These comments may reflect implicit strategies of forecast users and their efforts to reduce the cognitive burden of judgmental adjustments, or it may be that they implicitly attach a higher value to others' judgments. Irrespective of their reasons, however, users still adjusted a large number of the already-adjusted forecasts, but to a slightly lesser extent.

Provision of explanations for adjustment significantly affected both the size and frequency of forecast modifications. Users given explanations accompanying the adjusted forecasts appeared to have an increased acceptance of these forecasts, hence introducing smaller and fewer further modifications. This agrees with the findings of Gönül et al. (2006). Our participants particularly emphasized how seeing the explanations behind the initial adjustments contributed to their understanding of the behavior of the series, the forecasts given, and the adjustments conducted on them. They stressed that the explanations provided insights and highlighted specific points that they were not particularly aware of on their own.

In addition to the presence of an explanation, the information value attributed to it also has an impact on the adjustment/acceptance behavior. The more informative an explanation is perceived to be, the more influence it has on the users—as reflected in the frequency and size of adjustments. In case of a seemingly contradictory explanation, the reverse behavior in adjustments occurs—some participants commented that they especially adjusted more if they thought the explanation was somewhat contradictory or misleading.

The existence of original forecasts (in addition to their adjusted versions) appears to show similar effects to those observed with provided explanations. Having access to the original/unadjusted forecasts increases the salience of the adjustment and appears to give an information edge, leading to a better understanding of previous adjustments. This appreciation/understanding apparently facilitates their acceptance and leads to fewer modifications with smaller magnitudes. However, the effect size is quite small. Participants' comments indicated that the existence of original forecasts provided a different perspective/insight into the given forecasts,

enabling better comparisons, thus facilitating future modification decisions. There was a strong indication that none of the participants viewed the original forecasts as a further cognitive load or as a barrier. They seemed to prefer having access to this additional perspective. Furthermore, some subjects made their modifications to carry the forecasts somewhere into the middle of the original and adjusted predictions. This adjustment direction may hint at an important motive in the context of multiple adjustments. Such potentially influential factors may alter the serial/multiple adjustment process, presenting a promising direction for further research. Relatedly, effects of multiple adjustments on trends of adjustment magnitude as well as on trends in accuracy changes pose important questions for future work in this area.

The findings from both studies may have important repercussions for the forecasting processes in organizations. Forecasts that are generated in a particular unit and transferred through other units may undergo known or unknown adjustments. Our results suggest that believing a particular forecast has undergone a previous adjustment makes a difference for the latter forecast users, but only if explanations are attached. However, in the experience of the authors carrying out organizationally based forecasting research, while the original and adjusted forecasts are very commonly stored and accessible in the database, an explanation for the reasons behind the adjustment is very rarely captured and stored. Current findings suggest that such omission of explanations may seriously inhibit the effective propagation and use of forecasts, thus potentially deteriorating the quality of resulting decisions. The studies reported here provide preliminary investigations of user adjustment. Future work with practitioners in organizational settings will enhance our understanding of adjustment processes under the impending constraints of organizational politics, motivational contingencies, and informational externalities. Designing effective support systems for multitier forecasts relies on confronting and synchronizing the intricate processes behind forecast adjustment and communication. Further work in these venues will be imperative for improving organizational forecasting performance. [Received: January 2007. Accepted: August 2007.]

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