"METAFORECASTING: WAYS OF IMPROVING FORECASTING. Accuracy and Usefulness"

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C O M M E N T S

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Abstract

Forecasting has a long history. An understanding of such history, coupled with the study of the empirical evidence, can provide invaluable information for improving the accuracy and usefulness of future predictions. Statistical forecasting methods suffer by their inability to predict temporary or permanent changes from established patterns and/or relationships whilst people oscillate between ignoring and overreacting to such changes. Moreover, statistical methods do not utilize fully the historical information that data contains, while subjective forecasters are selective, biased, and inconsistent in the way they use such information. Also, while statistical methods are objective, people are influenced by personal and political considerations, wishful thinking, and what may be undue optimism or pessimism. Finally, both judgmental and statistical methods usually underestimate future uncertainty. This paper deals with these issues and their influence on forecasting. It discusses how forecasting accuracy can be improved by understanding and correcting the difficulties of statistical methods and past mistakes of judgmental forecasters. Furthermore, it looks at the complementarity of judgmental and statistical forecasting and the need to wed them, by considering their relative advantages/drawbacks along with the benefits of accurate forecasts, and the costs incurred through uncertainty and errors.

METAFORECASTING: Ways of Improving Forecasting Accuracy and Usefulness

Forecasting is an indispensable activity for planning, strategy, and all other forms of future-oriented decision making, both at the individual and organizational levels. At the personal level ranging from such trivial decisions, as the time to get up in the morning so as not to arrive late for work, to such important decisions as where to invest one's savings, require forecasting. Business decisions to build new factories, phase out or introduce new products, invest in new technologies, and a myriad of other considerations depend upon accurate forecasts. Similarly, governments determine monetary and fiscal matters, research funding, educational priorities, industrial policies and similar decisions based upon projections of future economic, technological, demographic and competitive conditions. It thus becomes important to be able to forecast as accurately as possible, and to know the best way of utilizing such forecasts to make more intelligent decisions.

The past few decades have witnessed some major developments in the field of forecasting. However, I am convinced that a deadlock has now been reached which will <u>not</u> be removed by small or marginal improvements. There is a strong need to go <u>beyond</u> available forecasting methods and practices by changing our approach and way of thinking about forecasting. This is what I call <u>metaforecasting</u>.

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Metaforecasting would require an understanding of the problems of statistical methods and the mistakes made by judgmental forecasters, so that new, imaginative, and realistic solutions can be found.

The paper is organized as follows: first, the perceptions and reality about forecasting are presented, with an emphasis on empirical evidence and the experience that has been accumulated through forecasting applications. Second, the extent of future predictability, and the factors that affect forecasting accuracy, are discussed. Third, the sources of forecasting errors and future uncertainty are outlined. A distinction is made between forecasting errors that are random, and those that result from temporary or permanent changes in established patterns and/or relationships. Fourth, common judgmental mistakes being made while making and utilizing forecasts are examined, their implications considered, and ways of avoiding similar mistakes in the future are proposed. Finally, ways are postulated for improving forecasting accuracy, both statistically and judgmentally, and the process of making and utilizing the forecasts.

THE PERCEPTIONS AND REALITY OF FORECASTING

In 1965, Paul Fama of the University of Chicago published an influential paper in which he proved that predicting stock market changes (i.e., increases or decreases from "today's" level) either as a whole or for any individual stocks, could not be done any better than using "today's" price as a forecast. This implies that investors cannot profit in the stock market through individual forecasts of stock prices, absent inside knowledge (an illegal activity). Fama proved scientifically what others before him had discussed, and what had been observed since the early 1920's. In actual comparisons, stock market experts and

professional managers do not outperform such market averages as Standard and Poor's 500 stocks. Indeed, the 1986 performance of institutional money managers climbed in value by only 16.9 percent while the S & P 500 rose 18.7 percent, beating out more than 67 percent of the managed funds surveyed (Wallace, 1987).

Even today, the great majority of investors (both individuals and institutions) still prefer a stock analyst or a professional manager to take care of their money. Although, by luck, some analysts or managers might do better than a market average for a certain period of time, all evidence suggests that consistent above-average performance is virtually impossible. This means that a random portfolio of stocks will, on average, perform as well as one that is selected by an expert. Few people, however, feel comfortable with a random selection to invest their life savings.

Forecasting is as old as human civilization. Humans possess a strong psychological need to want to know the future. This is partly due to a fear of the unknown and the anxieties accompanying such fear, and partly due to the realization that if the future could be predicted something could be done to be better prepared to face it, either by avoiding threats or by exploiting opportunities. Since early human history priests, prophets, augurs, fortune tellers, and astrologers have taken advantage of the human need to predict the future. These "forecasters" have managed to persuade their clients of their ability to make accurate predictions. This has been achieved by making predictions that are equivocal, general, or difficult to substantiate. Such predictions coupled with selective memory that better recalls those forecasts that turn out to be correct, has contributed in making many people believe that "prophecies" about the future are possible.

In modern times scientific reasoning has replaced superstitious belief, yet, enormous misconceptions still exist concerning forecasting and its ability to predict the future. Some of these misconceptions are widespread and not limited to the general public or the less educated. The stock market example and horoscopes are good illustrations of where misconceptions still prevail. Individuals and institutions feel more secure if they believe that someone can forecast the future for them. In holding such beliefs they either ignore the indisputable evidence, or they fail to take them at face value, or somehow they believe that the evidence does not apply to them. Some how people feel more comfortable in thinking that an expert is taking care of their money. They are inclined to believe that so-called expertise provides better protection against losses and can do better than the average of the market. The fact, however, is that they are worse off than if they had made cost-free random choices.

The example of the stock market is not unique. Future markets, exchange rates, interest rates, and numerous other variables cannot be predicted any more accurately than by taking the most recent value available as the best forecast for the future. A major activity within the field of forecasting has been the evaluation of hundreds of thousands of forecasts made in the past to determine their accuracy. The reality about forecasting that has emerged from this evidence is not what the great majority of people would like to believe. Although some events can be predicted with a high degree of accuracy, others are less predictable, or completely unpredictable. Individuals, business managers, and government administrators as users of forecasts, need to know specifically what <u>can and cannot</u> be predicted, since there are important consequences if the future turns out to be different from that for which plans have been made.

THE PREDICTABILITY OF THE FUTURE

Although some animals (for example bees and ants) do possess some concept of the future, humans are unique in their ability to comprehend and plan for a wide range of future events. Humans can predict the future by observing regularities in certain phenomena (for example, the daily sunrise or the seasons of the year), or causal relationships (cultivating seeds and growing crops, or intercourse and pregnancy). A prerequisite of any form of forecasting, whether judgmental or quantitative is that a pattern or relationship exists concerning some event of interest. If it does exist, the pattern/relationship has to be correctly identified and projected in order to forecast. When patterns/relationships do not exist, forecasting is not possible, although judgmental assessments based on similar past events can be made. Scientific progress has considerably improved our ability to predict future events, albeit, unevenly across various areas. In the frictionless natural/physical domain, forecasting accuracy is perfect for all practical purposes. In other areas and notably in the economic/business fields predictability ranges from excellent to nil.

In the frictionless physical/natural domain not only are patterns exact and relationships precise but, for practical purposes, they do not change over time. This, however, is not the case in the economic or business fields, where patterns and relationships are intermixed with random noise, and can change (sometimes considerably) over time. Two major aspects that causes patterns and/or relationships to change is the capriciousness of human behavior (e.g., shifts in attitudes fueled by fashions or differences among individuals) and people's ability to influence future events by their actions (the forecasts themselves can become self-fulfilling and/or self-defeating prophecies that change established patterns/relationships).

Exhibit 1 summarizes the factors that influence predictability and the characteristics of patterns/relationships, as a function of the events involved and the forecasting horizon. The longer the forecasting horizon, the greater the chance of a change in patterns or relationships, because people's behavior or attitudes can change, because there is more time to use the forecasts to change the future in order to achieve desired benefits, or because some fundamental changes in the environment, e.g., technology. Furthermore, Exhibit 1 describes some general factors that systematically influence predictability. These factors are briefly described below:

1. Number of items: The larger the number of items involved (all other things being equal) the more accurate the forecasts. Because of the statistical law of large numbers, the size of forecasting errors and therefore accuracy, decreases as the number of items being forecast increases and vice versa. Thus, it is more accurate to predict the number of telephone calls arriving at a switching station during a five minute interval than the number of Apple computers sold in a certain day.
2. Homogeneity of Data: The more homogeneous the data (all other things being equal) the more accurate the forecasts and vice versa. Thus, data referring to a single region can predict seasonality more accurately than data covering many regions of varying weather patterns. Similarly, sales of consumers goods only could be predicted more accurately than sales covering both consumers and industrial customers.
3. Elasticity of demand: The more inelastic the demand (all other things being equal) the more accurate the forecasts. Thus, the demand for necessities can be forecast with a higher degree of accuracy than that for non-necessities, and non-durable goods demand with a higher degree of accuracy than for durables. Related to the elasticity of demand is the influence

of business cycles. Such cycles the least impact on inelastic demand and most on elastic demand. People must eat and acquire necessities which are given priority over other purchases in case of income reductions, as during recessions.

4. Competition: The greater the competition (all other things being equal) the more difficult it is to forecast since competitors by their actions can use the forecasts to change the course of future events, thus, invalidating the forecasts.

SOURCES OF FORECASTING ERRORS AND FUTURE UNCERTAINTY

In frictionless physical/natural sciences the identification and verification of patterns/relationships is exact and objective. For all practical purposes precision instruments reduce measurement errors to zero, and laboratory or controlled experimentation allows keeping all factors, except the one being tested, constant. Moreover, feedback is unambiguous. In the economic and business domains, however, measurement errors abound, laboratory-type experimentation is not possible, and feedback is infrequent and often not clear. Furthermore, because of the complexity of economic/business situations, the inconsistency of human behavior, the varying time lags between actions and outcomes, and several other factors, forecasting errors much larger than those observed in natural/physical science are a fact of life. The size and persistence of such errors depend upon the following.

Erroneous Identification of Patterns/Relationships: An illusory pattern or relationship might be identified when none exists. This is possible both in judgmental and statistical forecasting. People in their quest to master and control the environment often see illusory correlation, while statistical models based on a small number of observations (as for instance with new products) can "identify" a pattern that is not maintained over a longer period. Similarly, a relationship between two variables might be spurious, existing only because a third factor causes both variables to move in the same direction. Alternatively, patterns or relationships that exist might be wrongly identified or ignored either because enough information/data is not available, or because reality is too complex to be understood and/or modelled with a limited number of variables (see Einhorn and Hogarth, 1987). Illusory or inappropriate identification can cause serious and persistent forecasting errors since the future could turn out to be very different from what had been postulated by an erroneous pattern or relationship.

Inexact Patterns and/or Imprecise Relationships: In the social sciences, for the reasons discussed above, patterns are not exact and relationships are not precise. Although an average pattern or relationship can be identified, fluctuations around such an average exist in almost all cases. The purpose of statistical modelling is to identify patterns/relationships in such a way as to make past fluctuations around the average as small and random as possible. Whether or not this is a good strategy is questionable (see below) but even assuming it is appropriate, it does not guarantee that future errors will be random or symmetric, or that they will not exceed a certain magnitude.

Changing Patterns/Relationships: In the social sciences, patterns and/or relationships are constantly changing over time in a way which, in the great majority of

cases, is not predictable. Changes in patterns and/or relationships can cause large and persistent errors whose magnitude cannot be known in advance. The size of such errors would depend upon the magnitude and duration of the change.

Uncertainty Caused by Forecasting Errors

Forecasting errors are inevitable in a wide variety of situations (see Exhibit 1). For planning and strategy purposes it is important to assess the size of such errors in order to minimize their negative consequences (e.g., having no products to sell, or accumulating large inventories). If it is assumed that the pattern/relationship (a) has been correctly identified and (b) would not change unpredictably during the forecasts, the errors around the average pattern or relationship can be found and their variance computed. In statistical models once the variance is known and if it is assured that the errors are (c) random, (d) normally distributed, and (e) constant, it is possible to assess the magnitude of future errors and, therefore, the uncertainty in forecasting.

The standard procedure used in statistics is to construct a symmetric interval around the most likely forecast of the identified pattern or relationship that would include the actual future value, say, 95% of the time. The range of this confidence interval denotes the normal uncertainty associated with the forecast if assumptions (a), (b), (c), (d), and (e) hold true. In such a case, forecasting errors are random. Furthermore, since it is assumed that they are and will remain constant and normally distributed, their size can be estimated for the great majority of cases (e.g., 95% of the time). Alternatively, it can be said that the actual value being forecast would be within the confidence interval postulated by the model 95% of the time. This postulated range defines the normal (covering 95%

of the cases) uncertainty to be the equivalent to the 95% confidence interval. But what about the remaining 5%?

On average, 5% of the time some actual values would be outside the 95% confidence interval postulated by the forecasting model. This involves an additional amount of uncertainty which inevitably exists but cannot be routinely incorporated into planning. Generally, it is too expensive to be constantly prepared to face large forecasting errors that would appear about one time out of twenty. Dealing with this unusual uncertainty would depend, to a great extent, upon the costs of ending up with extremely large overestimates or underestimates of the actual values (in an emergency room of a hospital, for instance, the cost of running out of a certain type of blood is much higher than having too much on stock). The costs of over or underestimating the future are not, in other words, symmetric. Although, often ignored, the 5% unusual errors must also be considered by forecasters and dealt with using a formalized approach such as a Bayesian framework.

When assumptions (a), (b), (c), (d) and (e) do not hold forecasting errors need not be random or symmetric. Furthermore, assessing their magnitude is not always possible since they can persist for several/many periods. Although, violation of any of the five assumptions mentioned above can cause non-random and non-symmetric errors, it is assumption (b) - constancy of patterns/relationships - that is the most critical. As it has been mentioned, in real life few patterns or relationships involving economic or business situations stay constant over time. Furthermore, although the validity of assumptions (a), (c), (d) and (e) can be checked it is not usually possible to do so with assumption (b). The start, duration and importance of changes in patterns or relationships, even if known to have

occurred in the past, cannot usually be predicted. Furthermore, unexpected changes that occur for the first time can also take place.

The process of estimating forecasting errors and future uncertainty judgmentally does not provide more accurate or precise answers than those of statistical models. One might expect experts to be able to assess forecasting errors and uncertainty in an accurate fashion. This, however, is rarely the case. Furthermore, the process used to make judgmental estimates of uncertainty is not well understood (Lawrence and Makridakis, 1978). People have difficulties in assessing forecasting errors realistically and dealing with their consequences. Forecasting errors and future uncertainty are topics people feel threatened by and do not, usually, approach them in an objective and rational manner.

The following is a list of major sources of change (both of a temporary and permanent nature) in established patterns and/or relationships, and therefore serious forecasting errors.

Special events: a fire, a major breakdown in machinery, an extremely cold winter or hot summer, and other similar environmental events can occur, over which one has little or no control, bringing changes in established patterns.

Special actions: special actions by the organization (such as an advertising or promotional campaign, the announcement of or an actual price increase, the introduction of a new product), or similar actions by competitors, can influence future events and modify established patterns or relationships. The effects of some of these special actions can be known while some others (in particular those of competitors) cannot be predicted.

Cycles: General and business-related variables are often influenced by economic cycles whose average duration is about 4.5 years, and possibly by long term cyclical waves whose duration can be as long as 50-60 years. Although cycles are repetitive, their duration and depth can vary considerably in a way that cannot be predicted except on the average. Cycles do, therefore, cause temporary drifts in established patterns and/or relationships and become a major source of errors and uncertainty in forecasting.

Fashions: Fashions and other fads can modify, in a substantial way, established patterns. By definition, the effect of fashions/fads is temporary and can become a source of huge errors in forecasting. For example, the exponential growing demand for C.B. radios or video games became negative in a period of a few months, causing huge errors in forecasting and bankruptcy of many companies predicting and having planned for a continuation of the exponential growth.

Technological and environmental change: Technological innovations, coupled with considerations about health and quality of life can bring fundamental changes in established attitudes and consumption patterns. This, coupled with governmental actions, (e.g., deregulation), increased specialization, and changes in international trade can bring fundamental changes in established patterns and/or relationships. In addition, political parties with various economic philosophies, consumer sentiments, fashions, the international political climate, and the international competitive structure can change over time in an unpredictable way causing drifts in long-established trends or long-held relationships.

Exhibit 2 summarizes the various types of forecasting errors and distinguishes three types of uncertainty (expected, unexpected and inconceivable), and it classifies changes in patterns or relationships as temporary and permanent.

Planning and strategy has to deal with all three types of uncertainty. The benefits and costs involved for being prepared to face each type of forecasting error versus the dangers associated with not being prepared to deal with such errors, need to be considered (see below).

COMMON MISTAKES IN MAKING AND USING FORECASTS

Forecasting users are discontent about large errors and the failure to be foretold of changes in the economy or in specific events. Their complaints are well founded and supported by many evaluations of past forecasts and their accuracy. Ascher (1978), for instance, found errors ranging from a few to several hundred percentage points when he evaluated GNP, population, transportation and energy forecasts. Moreover, he concluded that it was impossible to know before hand the most accurate method or forecaster. Furthermore, each forecast was based on several assumptions whose evaluation by a potential user was as time consuming as making new forecasts. Ahlers and Lakonishok (1983), Armstrong (1985), Hogarth and Makridakis (1981), Makridakis et al. (1982), Zarnowitz (1984), and Makridakis (1986), have reached similar conclusions after evaluating large numbers of forecasts made in the past. Does this evidence mean that forecasting is useless and should be abandoned as an activity or field? The answer is a definite no.

Abandoning formal forecasting would mean that predictions about the future would be done in an intuitive, or judgmental fashion, since forecasts are required, in one form or another, for planning, strategy and future oriented decision making. Empirical evidence (Armstrong (1985), Dawes (1986), Goldberg

(1970), Hogarth and Makridakis (1981), Makridakis (1986)) shows, in an unambiguous manner, that the accuracy of intuitive, judgmental approaches is not any better than that of statistical models in the great majority of cases. In addition, judgmental forecasts are much more expensive than equivalent statistical ones. Thus, we cannot shy away and because of problems abandon formal forecasting, since the alternative is even worse. Ways of improving the accuracy of formal forecasting must be found. As a beginning a clear understanding of existing problems and mistakes made in the past is needed.

Judgmental Mistakes

People can be easily persuaded that someone (person or method) can forecast for them accurately. Although, this might be possible in the domain of natural/physical sciences, it is rarely or never the case in people's personal lives, or the business/economic fields. Forecasting errors can result from many sources (see Exhibit 2) and cannot be eliminated by more sophisticated models, or by more gifted forecasters. Believing, therefore, that uncertainty can be eradicated through forecasting is dangerous and has no empirical backing. Worse it results in bad surprises.

Claims about forecasting accuracy and usefulness need to be checked against reality. Concretely, forecasting users must ask for specific evidence of how accurately the person/method did in correctly predicting changes in the event(s) of interest, as in many cases, it is trivial to predict the continuation of a prevailing condition. Furthermore, it is not enough to be told how well a model fits past data, or how accurately the forecasts have been over a limited range of time in the past. In addition, it is important to know how well the forecasts have done in predicting accurately not only the event of interest but also its

complement(s) (e.g., if someone always predicts a recession for the coming year, he or she would, inevitably, predict perfectly all recessions, but this does not mean much since he or she would be wrong in predicting the non-recession years). Unless these facts can be established it is dangerous to naively believe in claims of superior forecasting accuracy, or the alleged benefits from such forecasts.

Judgmental forecasts are much influenced by wishful thinking, and political considerations. Furthermore, judgmental biases are common in forecasting (see Hogarth and Makridakis, 1981; Moriarty and Adams 1984; Schnaar, 1984). Intuitive or judgmental forecasts can bring large and systematic errors caused by biases in the way information about the future is recalled and processed. Exhibit 3 lists the most critical biases affecting forecasting, and briefly outlines ways of reducing their negative consequences. Since no empirical work has been done to identify the most important judgmental biases relating to forecasting, those listed in Exhibit 3 are based on my own experience with judgmental forecasts made mostly in business organizations.

Exhibit 4 shows an example of a judgmental bias, recency. Recency effects have, for example, greatly influenced oil price forecasts during the last 20 years while basic economic considerations, substitution effects, and supply and demand factors have been ignored. The costs of such single bias in terms of actual expenditures, has been enormous (see Exhibit 4 for some examples). G.M., for instance, assuming that oil prices were going to continue increasing, has spent more than $60 billion since 1975 to come up with new, small, and gas efficient cars. It seems that the biggest part of this $60 billion has been wasted (Hampton and Norman, 1987), mostly because the forecast that the price of oil would keep

increasing turned out to be wrong. Mexico and several other oil producing countries went almost bankrupt in the early 1980's by basing their development budget on oil prices of $40 a barrel.

Statistical Models: Problems/Misconceptions

Statistical models assume constancy of patterns and/or relationships, or predictabilities in the way that changes will occur. This is a critical assumption which is not made clear to those studying or using forecasting. This assumption, although correct in the frictionless natural/physical sciences, is not realistic for the business/economic fields. Once constancy or predictability has been assumed, a model is fitted to past data. In methods originated in the field of statistics, modelling the choice of an appropriate model is guided by two criteria. First, the errors ought to be random; and second, the sum of the square errors for one-step-ahead forecasts ought to be as small as possible. It must be realized, however, that both of these criteria apply to past data, when constancy or predictability of changes has been assumed. There is no guarantee, therefore, that future errors will be random, symmetric, or within the range postulated by the variance of past errors, since future patterns/relationships can be different than those assumed by the statistical model.

Minimizing the one-step-ahead errors of a model fitted to historical data cannot assure that future errors will be minimal since constancy and/or predictabilities or patterns and/or relationships cannot be assured. The rank correlations between model fitting and forecasting for eight methods and eighteen forecasting horizons for the series in the M-Competition, for instance, are small to start with and become zero after the fourth horizon (Makridakis, 1986). Exhibit 5 shows the ranking among five methods starting at period 67 and going up

to period 126. At each period the best model that minimizes the one-step-ahead forecasting errors is fitted to the past data and then the rankings, of the five methods listed in Exhibit 5, for 1, 2, 3, 4, 6, 8, 12, 15, and 18 forecasting horizons are found. The rankings in Exhibit 5 show that no single method outperforms the remaining ones consistently. Furthermore, minimizing past errors can result in overfitting since many methods/models are tested before the one that minimizes past errors is chosen. Other problems associated with statistical methods include: (a) ignoring of sampling fluctuations in the selection of the appropriate model (b) assuming that minimizing one-step-ahead forecasting errors will automatically do so for two, three, four, ..., m-step-ahead ones, and (c) not utilizing all information contained in the past data (see Makridakis, 1986, pp.28-33).

Exhibit 6 shows a series (MNM61) of the M-Competition and the forecasts of eight methods of this competition. All methods (except single exponential) assumed that the uptrend in the data would continue and forecast appropriately. Single exponential smoothing assumed a "no change" approach and extrapolated a horizontal trend. Since the trend changed (see Exhibit 6, to the right of "Present") all methods except single exponential smoothing made enormous errors in forecasting. The reason that single exponential smoothing did better is not that it knew that a change in pattern would take place but because it always forecasts horizontally. Not much could have been done statistically with the data of Exhibit 6 to have predicted the sudden change in trend. In such a case only judgmental knowledge could have been used to predict the change in the data pattern.

Exhibit 7 shows a more interesting situation. The series involved (QND37) has been increasing substantially for five periods then in the last two it has

started declining. In such a case the forecasts of the same eight methods behave very differently. Some methods (Box-Jenkins, Parzen) completely ignored the decline in the last two periods, assuming it to be random, and extrapolate a continuation in the latest uptrend. Bayesian forecasting, however, decided that the latest downturn is permanent. Thus, it correctly predicted the change in the data pattern and produced forecasts that turn out to be the most accurate. The predictions of Holt's exponential smoothing are somewhere in between those of Box-Jenkins/Parzen and Bayesian forecasting. Regression ignored both the most recent uptrend and the latest decline assuming these to be random fluctuations around the long term trend. Single exponential smoothing, has, as always, assumed a "no change" attitude. In the final analysis, the forecasting accuracy of the various methods depended on the fact that the latest downturn continued during the eight quarters the forecasts were tested. This is not always the case, however.

The model fitting, one-step-ahead Mean Square Error (MSE), or the corresponding Mean Absolute Percentage Errors (MAPE), of Exhibits 6 and 7 give no indication of the impending disaster during forecasting. Furthermore, the confidence intervals constructed are too narrow and miss almost all actual values for most of the methods. The series in Exhibit 6 is very different from that of 7. In the series of Exhibit 6 there are no indications of the forthcoming downturn. In Exhibit 7, however, there are several indications during the past of temporary drifts from the established pattern. Forecasting in period 24 for periods 25-32, or in period 34, for periods 35-42, would have resulted in high errors similar to those during the forecasts for periods 41 to 48. Such information, however, was ignored by all forecasting methods which based their predictions on one-step-ahead forecasting errors and the fact that a change in data (uptrend and then a brief decline) has taken place in the recent past.

Combined Judgmental/Statistical Misconceptions

Contrary to widespread beliefs, empirical evidence has shown that predicting cyclical turning points is extremely difficult, or impossible, even at macro economic levels (Makridakis, 1982; Ahlers and Lakonishok 1983; McNees, 1979; Zarnowitz, 1984). The cycles that characterize many series are of varying duration and depths, and although statements about "average" behavior can be made, individual differences among cycles can be enormous. This makes "the next" turning point virtually impossible to predict, unless it occurs at a level that is close to the average of the past. Moreover, leading indicators do not provide consistent and advanced warnings of impending turns to be useful for forecasting purposes. Their biggest advantage is to confirm, after the fact, that a cyclical turn has occurred.

The belief that competitive behavior can be predicted (e.g., Porter, 1985) is optimistic to a fault (Put references). Although in the past, competitive actions in certain industries could have been inferred through competitive signalling, this is hardly the case for the great majority of industries, or the future. First, it is even difficult to define what constitutes competition. Second, competitors often give false signals. Third, competitors' behavior could change drastically during periods of worsening economic conditions when the need for accurate forecasting is the keenest. Fourth, external events (e.g., new technologies, legislation, exchange rates, foreign entrants etc.) that cannot be predicted in advance can substantially change the competitive structure of a given industry. Thus, the assertion that a model or a person can predict competitive actions is not supported either by empirical evidence or theoretical reasoning.

Finally, both statistical models and people tend to underestimate uncertainty. In statistical models the underestimation was the largest for yearly series (28 percent), the smallest for monthly ones (5 percent), and in between for quarterly data (25 percent) (Makridakis and Hibon, 1987). Moreover, the degree of underestimation depended very much upon the forecasting horizon. For yearly data the underestimation was 15, 25, 34, 39, 42, 45 percent for years 1, 2, 3, 4, 5 and 6 respectively. Judgmental forecasters also tend to underestimate uncertainty most of the time. Such underestimation is influenced by the complexity and familiarity of the task, and the involvement of the person making the forecasts (see Fischoff, Slovic and Lichtenstein, 1977, Lawrence and Makridakis, 1988).

Forecasting users should, foremost, be realistic in their expectations of forecasting. The errors and uncertainty involved with future predictions originates from many sources (see Exhibit 2) and cannot be eliminated no matter how much effort or resources are spent on forecasting. Preparers of forecasts must also become better aware of the limitations of their techniques and make them clear to forecasting users. It is important that no false expectations exist as to what judgmental and statistical forecasting can and cannot do. Uncertainty must be accepted and its consequences considered while planning and formulating strategies (see below).

Exhibit 8 summarizes a great deal of the preceding discussion. It also lists common mistakes made in the past and ways of avoiding them, classified according to forecasting horizons. In summary, in the short term, the major mistake has been to ignore special events and actions and their implications on planning. In the medium term, the major mistake has been to ignore cycles, or other turning points, and their implications for planning and strategy. Finally, in the long

term, managers have oscillated between an inability or unwillingness to introduce new technologies, and prematurely investing in new technologies which turn out not to be commercialy viable. This has been particularly true when managers are over-dazzled by the alleged technological wonders of new inventions whose importance and applicability they tend to overestimate. Berenson and Schnaars (1986) in a large study of forecasts made between 1960 and 1980 concluded that the majority of long term new product forecasts failed because of unbridled optimism in terms of overvaluing new technologies.

IMPROVING THE MAKING AND UTILIZATION OF FORECASTS

The challenge that lies ahead is to correct existing problems of statistical methods, and to avoid repeating past mistakes. At the same time it is necessary to eliminate or lessen the disadvantages of statistical and judgmental forecasting while simultaneously exploiting to the maximum the advantages of each.

M-Step-Ahead Actual Forecasts

A novel approach to statistical forecasting would be to choose four or five appropriate methods not excluding methods that minimize one-step-ahead, model fitting errors. Such methods should be complementary in their ability to accurately predict specific characteristics of the series being forecast. Then, instead of selecting the method that minimizes the one-step-ahead Mean Square Error (MSE), or Mean Absolute Percentage Error (MAPE) of the historical data, the actual forecasting accuracy for m forecasting horizons can be computed. This can be done using the Jackknife approach which start at some early period and proceeds by presuming that the values beyond this period are <u>not</u> known.

An appropriate model for each of the methods can be found and m forecasts made at each period of the Jackknife forecasting simulation. The accuracy of such forecasts can be computed since the actual values are known. The same process can be repeated using one more data point to estimate the model and make anew m forecasts. This forecasting simulation can be continued until all but one of the data points has been used. It is illustrated schematically in Exhibit 9. The end result of the forecasting simulation would be a series of m forecasts for k periods ($k = n - s$, where n is the number of data points, and s is the starting period for the simulation). As indicated in Exhibit 9, the average of the MAPE's (or MSE's or any other desired accuracy measure) for each of the m forecasting horizons can be computed. In addition, the average of the average MAPE's can also be found. The procedure outlined above allows the following:

1. Realistic accuracy measures (and variances for confidence intervals) based on actual forecasting performance.
2. Accuracy measures based on m-step-ahead forecasts, not just one-step-ahead.
3. The sampling variation (standard error) of the accuracy measures on each of the m-step-ahead forecasts.
4. A rationale for combining different methods if it is found out that their accuracies are not significant in a statistical way.
5. The ability to use a preferred method, as long as the statistical evidence does not suggest rejecting the null hypotheses that such a method is the best.
6. A flexible selection process that permits combining various selection criteria.
7. The ability to select a different method, or model, for each of the m forecasting horizons, if so desired (it is not necessarily true that the method that does best for a one-step-ahead forecasting horizon will also do so for two, three, ..., m-step-ahead forecasts).
8. An ability to understand how the data behaves, by knowing the performance of each method in the various accuracy measures and forecasting horizons. Such ability can let us know if changes in patterns and/or relationships have occurred in the past.

The only disadvantage is the amount of computing time required to do the simulation. This time can be high since several methods are used and many forecasting simulations are made. Nevertheless, the cost of computing is rapidly

decreasing and the availability of computers is increasing so the problem posed can be overcome if reasonably simple methods are selected. Furthermore, once the simulation is done once its results can be updated recursively. Finally, the empirical evidence shows that it is not necessary to re-optimize the model parameters at each step of the simulation.

Although additional research is required the results I have obtained so far are extremely encouraging. Using single, dampen-trend (Gardner and McKenzie, 1985), Holt, and quadratic exponential smoothing, and an autoregressive method capturing the long term trend I come up with results that beat all methods in the M-Competition in a variety of criteria (a paper currently in preparation describes the approach and presents the results). For instance, the best overall MAPE for all forecasting horizons (by simply combining the best three methods for each horizon) is 13.6%. The same MAPE for Parzen's ARARMA models (the best method in the M-Competition) is 15.4%. The improvement of 1.8% is more than the improvement of ARARMA models over single exponential smoothing (whose corresponding MAPE is equal to 16.8%) of 1.4%. I expect that further work on improving the selection criteria and the methods to be included should increase accuracy even more. In my judgment, the simulation approach I suggest here is the only realistic way to select a forecasting method(s).

Dealing with Systematic Changes

The Jackknife approach can indicate changes in established patterns, and/or relationships. This can be inferred by the size of the MAPE's, the size of MSE's, the percentage of series outside any confidence intervals, the size of bias (mean percentage error), and the ranking of the various methods during the simulation. For instance, if the MAPE or MSE of longer forecasting horizons is much bigger

than short ones it would mean cyclical turns in the data. Similarly, if the data have a strong linear trend but single and dampen-trend exponential smoothing does better than Holt, this implies cyclical or other turns. Moreover, if in the ranking of the methods single exponential smoothing does the best until a certain period and then Holt does best, this would signify a change of pattern from a constant level to one with a trend. If the MSE's for a given forecasting horizon of linear or quadratic smoothing are relatively bigger than the MAPE's of single and dampen exponential smoothing, this would probably mean an unexpected turn that was missed by the methods with the large MSE which extrapolate the most recent pattern, thus making large errors for longer forecasting horizons when a pattern change takes place.

If no indication of pattern changes can be inferred from the past data, and if no judgmental knowledge exists, nothing can be done if a pattern change occurs in the future. The series in Exhibit 6 is a clear case of that. If however, pattern changes can be inferred from the past data (as in the drifts shown in Exhibit 7) and/or be known to management as forthcoming, their impact can be taken into consideration. Knowing that pattern changes have occurred in the past and/or are forthcoming in the future cannot guarantee that the timing of such changes, or their impact, can be predicted adequately. A cyclical series that can be identified as such could, for example, indicate the possibility of a future recession. The problem, however, is that the timing, duration, and depth of the recession might not be predictable. In this case, however, the average duration and depth of past recessions can be found and used for planning purposes, particularly if deviations around the average are also known. Similarly, airline deregulation or the break-up of AT & T, say, indicated a fundamental change in established patterns <u>and</u> relationships. Still, the specifics of such changes, or their impact on individual variables/events, could not have been predicted.

Developing and Using Appropriate Models

Some simple rules need to be followed in developing appropriate forecasting models and in their subsequent use. First, models should not be "black boxes." Forecasting users are less likely to utilize models whose forecasts they do not understand. Thus, intuitive models should be preferred to non-intuitive ones. In my experience, a major reason for the attractiveness of decomposition methods, linear trend extrapolation, and single or Holt's exponential smoothing among practitioners is the intuitive understanding of the forecasts of these methods. The contrary is true with ARIMA models whose forecasts are "black boxes."

Second, models should be developed in terms of predicting changes. (This is particularly true with regression-type explanatory models). Modelling changes reduces the chances of spurious interpretation of correlations and provides more realistic measures of how well the model can predict the future. When models cannot be expressed in terms of changes (as in time series) a benchmark model is necessary. Such models can be the equivalent of forecasting that "tomorrow" will be the same as "today" (that is a random walk, or what I call the Naive 1 method), or alternatively that "tomorrow" will mirror "today", after seasonality has been introduced (i.e., the Naive 2 method). More complex models can, then, be compared to these simple benchmarks (Naive 1 or Naive 2) to determine the extent of improvement and whether the extra accuracy justifies the extra cost of the more complex model.

Third, explanatory models do <u>not</u> necessarily forecast accurately when their R^2 is high. For example, a model might explain perfectly ups and downs in sales, by relating sales to changes in GNP and changes in prices. The forecasting value of this model might be nil because changes in GNP and prices are usually not known

in advance. Moreover, suppose the explanatory model postulates that a decrease in price by $1 would increase sales by $25. Would this prediction materialize? The answer, in the great majority of cases, is no. Since it is most likely that competitors would also decrease their prices, thus invalidating the model forecast which assumes that competitors would do nothing.

The value of explanatory models is in helping us to better understand and measure what causes sales to go up and down. Such an understanding is essential in helping us to assess future uncertainty, and in taking steps to be prepared to face, changes in patterns and/or relationships while forecasting. Although this is where the biggest value of explanatory models lies, such value is not being adequately exploited. Instead explanatory models are used to forecast with unsatisfactory results, at least at the level of business firms.

Finally, when forecasting is not possible (as, for example, in predicting cyclical changes) the next best alternative is to monitor the event(s) of interest as precisely and timely as possible. Such monitoring would allow us to determine changes from established patterns and/or relationships and give us early warning of persistent errors in forecasting so that appropriate actions can be taken.

Judgmental Considerations

By nature people are optimistic. Furthermore, personal and/or political considerations influence forecasting to a great extent. Thus introducing objectivity must become the first and paramount concern in improving forecasting accuracy. Objectivity can be introduced either by asking a third party to make the

forecasts, or by having more than one person independently predict the event of interest.

It is often claimed that sales forecasts are purposely inflated in order to motivate the marketing force to achieve the optimistic forecasts. Although there might be some benefits from high forecasts, the negative consequences are considerable since the forecasts drive production schedules and result in high inventories. Thus, unless sales forecasts can be separated from the scheduling and/or production planning process it does not seem beneficial to deliberately inflate future predictions. Another justification marketing people often advance for their undue optimism, is that sales margins are so high that it makes no sense not to always have adequate inventories at hand. This claim might have had some value in the 1960's, but, it becomes less and less valid as competition increases and the need to cut costs increases.

Little work has been done on debiasing judgmental forecasts. My approach to doing so is based on three principles (see also Exhibits 3 and 4):

Anchoring the forecasts: Start the decision making process of arriving at final forecasts by presenting a set of objective, statistically-based forecasts. Explain to the decision makers that these are the best possible forecasts when it is assumed that the future will not be very different than the past. Then ask them to use their knowledge of the company, market and economy to determine how these forecasts should be modified. Also ask them to state reasons for such modifications. Furthermore, I have found out that if I ask the executives to write their answers on a piece of paper anonymously it is much easier to avoid having some of them stick to stated opinions when there is no agreement about changing the statistical forecasts.

Presentation of Information: Information should be presented in a way that brings out all important aspects of the situation being considered without, simultaneously, providing unnecessary details. Up-to-date information about the evolution in sales, prices, competition, economy, etc. needs to be presented, preferably in a graph form. Such information should use deseasonalized data highlighting established trends as well as pattern changes, (recessions or booms, changes in trends etc.). Often I find it useful not to ask managers to come up with numbers, but rather to request that they trace their forecasts on the graph of deseasonalized (or trend-cycle) historical values and have such forecasts recorded from there. This is especially useful when budget forecasts are made, since the common practice of basing forecasts of growth rates from the previous year's level can provide misleading forecasts (see Makridakis, 1986, pp. 24-29).

In addition to specific forecasts, the various types of forecasting errors and future uncertainty need to be considered in meetings where managers finalize forecasts. To do so, previous errors must be presented and cases where substantial mistakes were made given. The argument that managers should not be made aware of the true range of confidence intervals because they will be less willing to believe in the forecasts, is, in my opinion, entirely wrong. Knowing the true uncertainty would allow them to take steps, if necessary, to deal with such uncertainty in a realistic way.

Keeping track of judgmental errors: Unless people are provided with feedback they are unlikely to improve their ability to forecast accurately. I therefore suggest to forecasting users that their modifications of statistical forecasts be recorded to realize what went wrong or to determine the extent of their improvements over the statistical forecasts. In doing so I emphasize that this is done not to blame

them if they go wrong, but, instead as a way of providing feedback and facilitating learning and future improvements. As a matter of practice, the feedback is provided only to the individual involved and in no way it is made public.

Statistical Models versus Judgment

There is little doubt that there are advantages and drawbacks in the way that both statistical models and people forecast (see Exhibit 10). The challenge ahead lies in our ability to use to optimal advantage both statistical models and individual judgment while avoiding their drawbacks. Doing so would involve the following.

People must decide what method or model to use. Such a choice is not value free as it has a major impact on the forecasts (see Exhibits 6 and 7). Adaptive models, for instance, are reactive, overemphasizing non-random changes in the recent past. Single exponential smoothing provides conservative forecasts, as it assumes a horizontal extrapolation. Trend regression, in contrast, ignores pattern changes emphasizing the long term trend in the data. Similarly, for forecasting purposes there is a big difference if a logarithmic transformation is made, how the data is differenced, or if an autoregressive versus a moving average ARIMA model is selected. The implications of such choices are enormous for forecasting and, if not known, need to be verified using the type of Jackknife simulation suggested above.

Since statistical methods cannot predict changes in patterns and/or relationships, nor distinguish if they are temporary or permanent, it becomes necessary for people to do so by selecting appropriate models, and incorporating their own

judgments to modify the statistical forecasts. Models chosen might differ depending upon the forecasting horizon and the period of time for which the forecasts are being made. Thus, an adaptive model might be selected for the short term, a model that dampens the trend for the medium term, and an autoregressive model with many parameters for the long term. Moreover, single exponential smoothing might be preferred when cyclical, or other non-seasonal turns whose timing cannot be known are thought to be forthcoming.

Predicting changes in patterns and/or relationships is another human task. Plotting the data and the Jackknife approach suggested above would allow the identification of changes that have occurred in the past. The major consideration of judgmental forecasters is the need to consider when similar changes might also occur in the future, and/or when brand new ones might take place. Similarly, they must realistically assess the forecasting errors and uncertainty that would be caused by such systematic changes. This is the most critical task of forecasting users, since statistical methods are not suited in predicting changes in patterns and/or relationships.

The forecasting process can be rationalized if people concentrate on predicting the influence on forecasting of changes in established patterns and/or relationships, while statistical methods specialize in predicting continuations of such patterns/relationships. Furthermore, it would be necessary to formalize the forecasting process by adapting a consistent approach in dealing with changes. The need was mentioned for more than one person being asked to independently predict forthcoming changes in patterns and/or relationships and their effects on the future. Along the same lines a committee can be formed to search for new, major changes that are forthcoming and consider their possible consequences. Such a search should be guided by identifying important problems (disequilibria) in the

economy, critical legislation that might be enacted, new competitive forces, emerging fashions/fads, and new technological innovations.

Finally, the historical data used to develop the statistical model need to be consistent and adjusted judgmentally for special events and/or actions. Data need be refined to be consistent from its beginning to end. Changes in accounting procedures, changes in definitions of what constitutes a division, product family, product group, etc., must be recorded and their effects estimated. Past data need, consequently, be adjusted so that they are consistent throughout. Furthermore, judgmental adjustments must be made for special events and actions. The influence of a strike or an extremely cold winter that will not repeat itself for another twenty years needs to be removed from the data while forecasting. This needs to be done by estimating judgmentally the effect of such an unusual change and adjusting the actual data accordingly. At the same time, the original values need to be kept to warn us of unusual changes and their influence on forecasting errors. Keeping track of special events or actions and their influence can, in addition to eliminating what otherwise would be considered randomness by the model, facilitate the estimation of how similar future special events or actions would influence the forecasts.

FORECASTING, PLANNING AND STRATEGY

Forecasting users often complain that too much uncertainty about the future makes planning and strategy extremely difficult or impossible. Although it is true that uncertainty in forecasting can be huge, there is not much the preparers of forecasts can do apart from pointing out that it is not realistic to pretend

that future uncertainty does not exist, or that it can be eliminated. It is, however, extremely useful to evaluate not only the average forecasting errors, but also the large ones so that uncertainty can be better understood and the risks involved with future predictions considered. Decisions can then be made in such a way as to minimize the risks pointed out through forecasting, since positive and negative errors while forecasting do not carry the same risks for given organizations. Furthermore, one extremely large error does not usually have the same impact as two errors that sum to the same amount.

Although uncertainty is psychologically difficult to deal with, decision and policy makers must heed Russell's advice to learn "how to live without certainty, and yet without being paralysed by hesitation". Ignoring or pretending that future uncertainty does not exist is not realistic and would inevitably result in unpleasant surprises.

Dealing with future uncertainty in a realistic manner requires considering the trade-offs involved in making different kinds of forecasting errors. In considering, for instance, the possibility of investing in a new technology there are two types of risk. One alternative is to decide that it is not worth investing in the new technology. In such cases competitors can gain an edge if they introduce the new technology and it is successful. By introducing the new technology, however, one can incur serious losses if it is proves to be a flop, or if it turns out not to be commercially viable. Both types of errors can be costly and managers must consider both possibilities.

During the past, both types of mistakes have been made (see Berenson and Schnaars, 1986). Berenson and Schnaars suggested that forecasters must consider

several simple guidelines in evaluating the advantages and dangers of new technologies. Fundamental questions such as: Who are the customers? How large is the market? What benefits the new technology provides over those of existing ones? Are these benefits worth the extra price, or the resistance in people to change to new products or services? Would the demand for the products or services of new technologies continue beyond the initial craze? Would the competition be rough (this is true in particular in high-tech areas)? Such questions can help one to evaluate the possible economic rather than the technical benefits of the new technologies.

Examples of both ignoring new technologies, and losing great amounts of money by investing in them, abound. AM International Inc., for instance, completely ignored the photocopying technology being introduced by Xerox, lost its leading market position and eventually went bankrupt. Nuclear energy, picturephones, plastic paper, synthetic oil and many other highly-regarded technological innovations did not produce the expected benefits and might be long before they become a commercial success. Moreover, in high-tech and high-growth markets, competition is extremely keen causing innumerable bankruptcies and/or little profits even if a forecast about a technological invention turns out to be accurate.

The opportunities and risks of new technologies are different for established versus new companies. It would have been easy for AM International to acquire the new photocopying technology, or diversify to new markets when it was in a leading position and possessed strong financial and competitive advantages (e.g., a large distribution and repairs network). It did not do so, however, because its management ignored the new technology until it was too late. Xerox, in contrast, had no choice but to embrace the new technology and market it as forcefully as possible as it had no other way of replacing AM's leading market position.

Products or services whose growth is temporary and which depend upon fashions and other fads are even more difficult to deal with than new technologies. Fashions or fads start suddenly and might end even faster. Thus, trying to predict them is extremely difficult which makes the forecasting errors and the resulting uncertainty huge. Should a company invest to exploit a fad? This is a difficult situation that can only be dealt with by considering the risks involved for the specific company and whether or not its management is willing to accept them.

Recessions provide similar dilemmas for management. If a recession is predicted, production (and expenditure) is cut. If the recession materializes the right decision has been made. If the recession does not take place production might not be sufficient to fill orders and customers might be lost to competitors. If no recession is predicted and one occurs inventories would be high and profits low or negative. Some companies might not even be able to ride the recession through and might have to cease operations because of cash flow or other financial problems. Managers need to consider the costs of predicting a recession that does not occur as well as the costs when a recession is forecast and does not occur. The costs involved are not symmetric, thus the risks are different in each case and, to a great extent, depend upon the specific organization involved, its financial strength and the values of its management.

Organizations must be prepared to face errors caused by changes in patterns and/or relationships in a general way since they cannot know when and how large such error might be. Flexibility and financial strength are important ingredients in dealing with unlikely or unexpected events, and need to be built as an integral part of organizational strategy. Japan and Germany were two countries least affected by the oil crisis (an unexpected event) and the large changes it produced

on established patterns and relationships. Although both countries import all their oil, they managed to ride out the crisis well because of their strong financial positions and their good international competitive postures.

Strategies need to consider the dangers of being wrong in forecasting, as well the possibility of unexpected and/or inconceivable events occurring in the future (see Exhibit 2). Furthermore, strategists have to come to grips with the amount of risk they would be willing to assume by considering the trade-offs and risks involved in any future oriented decision. In the final analysis, there is no such thing as a free lunch. In an uncertain environment gains cannot be made without taking risks. The role of forecasting is to point out and help management assess uncertainty and risks, but cannot eliminate uncertainty. The future can always turn out to be different than forecast.

The roles of forecasting, planning and strategy are interrelated. The more accurate the forecasts, all other things being equal, the more effective the planning and the lesser the need for a strategy. In an uncertain environment, however, when large non-random errors are possible planning can go wrong and uncertainty is high, thus making the need for an effective strategy imperative. Conventional approaches to strategy advocate identifying and exploiting opportunities in the environment, while, simultaneously avoiding dangers. The latter assumes accurate forecasting of the opportunities and dangers, and also accurate predictions of competitors' actions. Assume, for instance, that an opportunity in the environment is identified and a company invests heavily to exploit it. This would not guarantee profits even if the opportunity has been predicted correctly, if existing competitors and new entrants have also decided to invest in the same technology. Overcapacity, price wars and similar events caused by competitive factors can change the opportunity into a disaster. At the same time consider a

danger such as the slowdown or negative growth in a certain market. If the forecasts drive the majority of competitors out of the market can bring a golden opportunity to those that have decided to stay (Makridakis and Heau, 1987).

CONCLUSIONS

In this paper I have argued for a new approach going beyond available forecasting methods and practices. Forecasting users must become realistic by accepting that uncertainty in any future oriented prediction can be huge. They should understand past mistakes and the illusory quest by people to eradicate future uncertainty. Furthermore, forecasting users ought to avoid judgmental biases. Preparers of forecasts need to better understand the problems of the forecasting methods currently in use and devise ways of avoiding them. In this paper I have argued for an approach that simulates the testing of forecasting models so that a realistic assessment of forecasting errors, and a more accurate method selection can be made. Moreover, preparers of forecasts will have to better explain to users the limitations of statistical models, and discuss their implications for predicting the future. In addition, a serious effort would be required to formalize the task of forecasting by utilizing the best of statistical methods and individual judgments, while avoiding, as much as possible, their deficiencies. Finally, forecasting users must consider the trade-offs involved in making various types of errors and the resulting uncertainty, so as to operate at some acceptable level of risk consistent with their corporate philosophy.

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EXHIBIT 1: Extent /Ability to Forecast and Factors Involved

Events/situations that can be forecasted for all practical purposes, with a perfect degree of accuracy	Forecasting Horizon	Events/situations that can be forecasted with a high degree of accuracy	Events/situations that can be forecasted with a medium degree of accuracy	Events/situations that can be forecasted with a low level of accuracy	Highly inaccurate forecasting of events/situations	Unable to forecast more accurately than utilizing the most recent actual values to do so	Unable to forecast more accurately than statistical (actuary) averages	Unable to forecast at all
Frictionless Natural/Physical events/phenomena (e.g., the exact arrival of Haley's comet or its nearest distance to the Earth; the exact time of sunrise a day, month or year from today; The result of putting two atoms of hydrogen and one of oxygen together).	SHORT (up to 3 months)	Large numbers of items (products, customers, services) ←(a)→ Small numbers of items Highly aggregate quantities ←(b)→ Single items				Events determined by the collective actions of many individuals/ organizations (attempting to maximize their benefits) when information is disseminated efficiently (e.g., the stock and futures markets, exchange rates, prices of almost all raw materials and most finished products).	Unusual and/or infrequent events (e.g., a fire destroying one's home or a factory; A major car accident; The accidental death or a young, healthy person; An extremely big snow storm).	Unexpected or inconceivable events (e.g., The growth and importance of computers to someone before 1950; The oil crisis to a decision maker in the 1960's; The fall of the Shah of Iran to a political analyst before 1970).
	MEDIUM (3 months to 2 years)	(a) and (b) Forecasting horizon close to 3 months ←(c)→ Forecasting horizon close to 2 years Inelastic demand ←(d)→ Elastic demand No competition ←(e)→ Strong competition						
Characteristics of patterns/relationships . Patterns or relationships do not change over time. . Events cannot be influenced by human actions. . Patterns are exact . Relationships are precise.						Characteristics of patterns/relationships . Patterns and relationships change over time. . Events can be influenced by human actions. . Patterns are not exact. . Relationships are not precise.	Characteristics of patterns/relationships . Aggregate patterns (involving large #'s of cases/people) exist. The larger the numbers involved the more precise the pattern and vice versa. . Patterns might change over time but usually do so slowly. . Relationships are weak or non-existent.	Characteristics of patterns/relationships . Patterns and/or relationships do not exist, or they cannot be identified given today's knowledge.
	LONG (2 years or more)	(a), (b), (c), (d), and (e) Forecasting horizon close to 2 years ←→ Forecasting horizon of many years Low degree of technological change ←→ High degree of technological change Strong barriers to entry ←→ No barriers to entry						

Characteristics of patterns/relationships

Patterns/relationships vary widely (ranging from those listed in the column on the left side to those listed in the three columns on the right) depending upon the factors specified above.

Exhibit 2: Forecasting errors and types of future uncertainty.

Types of Future Uncertainty / Forecasting errors caused by:		Expected		Unexpected	Inconceivable
		Normal	Unusual		
Random Fluctuations		95% of the errors around the average pattern or relationship.	The remaining 5% of errors. That is large errors that would occur, on average about one time out of twenty.	A not too serious car accident.	
Changes in Patterns/Relationships	**Temporary**	Special events (e.g., a colder than average winter) & special actions (e.g., a promotional campaign, a new product introduced by a competitor etc.)	An "average" recession not too different to previous ones. A fire.	A serious recession of the 1974/75 type. The energy crisis for planning and strategies considered at the end of the 1970's).	The 1973/79 energy crisis (for planning and strategies being considered in the 1960's).
	Permanent	Gradual changes in consumer attitudes and buying trends caused by technological innovation and concerns about health and quality of life.	Big changes in attitudes and buying trends caused by new technologies, or governmental intervention (e.g., the deregulation of the airline industry at the end of the 1970's).	A collapse of the international financial system. The industrial revolution for people living at the beginning of the 18th century.	A large meteorite hits and destroys life on Earth. A major nuclear accident or war destroying life on Earth (to someone living before 1930).

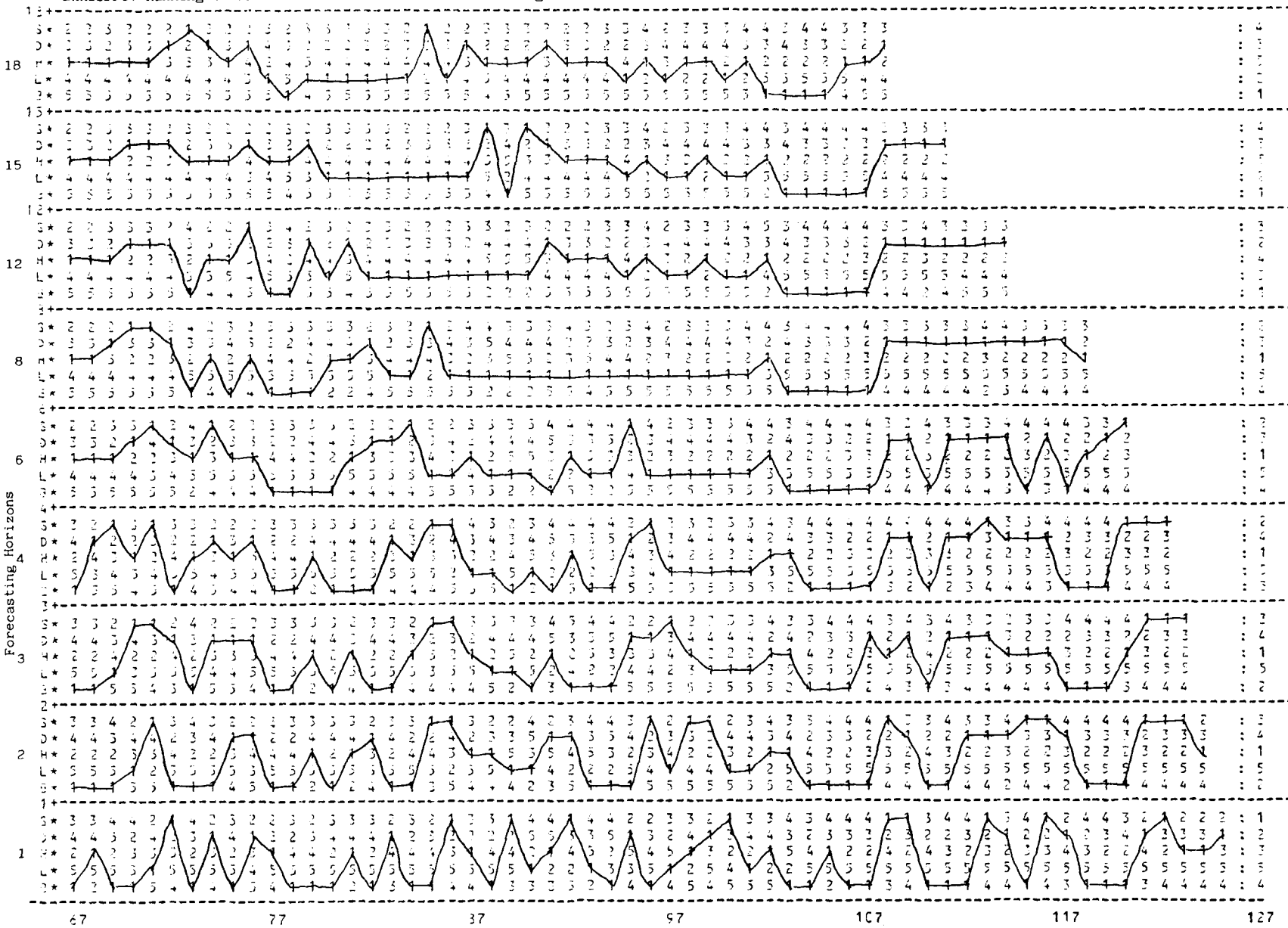
Exhibit 3 : **Common biases in judgmental forecasting and proposed ways of reducing their negative impact.**

Type of Bias	Description of Bias	Ways of reducing the negative impact of Bias
Optimism, wishful thinking	People's preferences for future outcomes affect their forecast of such outcomes	. Have the forecasts made by a third, uninterested party . Have more than one person independently make the forecasts
Inconsistency	Inability to apply the same decision criteria in similar situations	. Formalize the decision making process . Create decision making rules to be followed
Recency	The importance of the most recent events dominates those in the less recent past which are downgraded or ignored	. Realize that cycles exist and that not all ups or downs are permanent . Consider the fundamental factors that affect the event of interest
Availability	Ease with which specific events can be recalled from memory	. Present complete information . Present information in a way that points out all sides of the situations be considered
Anchoring	Predictions are unduly influenced by initial information which is given more weight while forecasting	. Start with objective forecasts . Ask people to forecast in terms changes from statistical ones and demand the reasons for doing so
Illusory correlations	Belief that patterns exist and/or two variables are causally related when it is not true	. Verify statistical significance of patterns . Model relationships, if possible, in terms of changes
Conservatism	Failure to change (or changing slowly) one's own mind in light of new information/evidence	. Monitor systematic changes and build procedures to take actions when systematic changes are identified
Selective perception	People tend to see problems in terms of their own background and experience	. Ask people with different backgrounds and experience to independently prepare the forecasts
Regression effects	Persistent increases or decreases might be due to random reasons which, if true, would increase the chance of a change in trend	. Explain that when errors are random the chances of a negative error increases when several positive ones have occurred

Exhibit 4: OIL PRICES AND OIL FORECASTS

Year	Actual oil prices	Reasons for prevailing prices	Forecasts make for future periods and their reasoning	Economic facts ignored in the 1950-1987 period
Before 1970	Between 1950 and 1970 oil prices (in current dollars) did not change.	Multinational oil companies (mostly the seven sisters, as they were called) had complete control of oil production and therefore supply. It was in their interest to keep oil prices low and so they did	Prices will continue to be cheap or at least they will grow below inflation and energy supply will be abundant	. The importance of long term economic forces was ignored This was done before 1970 when the cartel of oil companies and its ability to maintain low oil prices was not questioned . After 1973 decision makers over reacted to the price increases in oil. They assume that prices will continue increasingly at high rates, or in the best of scenarios 1-2 % above inflation. . The fact that similar producers' cartels have not workedin the past was not taken into account. . The importance of basic economic laws (e.g., higher prices increase supply and decrease demand) was not used in making oil price forecasts
1971 to 1973	Oil prices were raised from $ 1.80 in 1970 to $ 3.30 in 1973.	OPEC becomes a cohesive cartel (to a great extent as a reaction to the existing cartel of oil companies). Prices are raised to make up for the lost buying power as oil prices had not followed increases in inflation	Oil prices will increase to follow inflation. Although energy will not be as cheap as before 1970 no major problems were envisioned. OPEC's share of the market in the year 2000 was forecasted as 66.7%	
1974 to 1978	A huge increase brought the price of a barrel of oil to $ 11.60. It was followed by several smaller increases bringing the price to $ 13.	The 1973 Arab-Israeli war is used as an excuse to raise prices by 300% OPEC becomes a major political force internationally. The trade surplus of oil producing countries reached many billions of dollars	Since oil was going to run out soon it was natural and its price was going to go up. Prices of $ 50 per barrel of oil by 1985 were common. OPEC's share of the oil market in the year 2000 had dropped in the mean time to 55%	
1979 to 1981	Another huge increase in 1979 raised the price of a barrel of oil to $ 30 Several smaller increases brought prices to a record $ 36 a barrel.	OPEC, by controlling production, kept raising prices. Industrialized nations and third world countries become hostages of OPEC pricing decisions	Prices will continue rising above inflation. Forecasts of $ 65 in 1990 and $ 333 by the year 2000 were common. OPEC's share of the world market in the year 2000 had dropped further to 30%	Typical mistakes made in the 1950-1987 period . Utilities switch from coal to oil in the sixties and back to coal in the seventies . Oil producing countries (e.g., Mexico) went almost bankrupt by basing their development budget on oil prices of $40 or more. . Oil consuming countries (e.g., Japan) negotiated long term contracts to purchase oil at $30 or $40 a barrel . R & D projects were initiated for developing new energy sources. Those projects were abandoned as oil prices dropped . New exploitations of oil fields bought at high costs were abandoned . Hugh investments made to extract oil from tarsands, shale oil, synthetic oil etc. were abandoned with losses in the billions of dollars
1982 to 1985	Oil prices started decreasing. By end of 1985 the price of a barrel of oil was $ 28	Energy conservation, new oil discoveries, alternative sources of energy, smaller and more efficient cars and decreased consumption because of higher prices decreased demand for OPEC oil and reduced OPEC's economic & political power	The tempo of increases in oil prices will slow down but it will still be 1-2% above inflation. In the mean time the forecast of OPEC's share in the year 2000 had dropped to 20%	
1986 to 1987	Prices of oil tumbled. After having dropped to as little as $ 10 a barrel they finished at $ 13 a barrel by the end of 1986.	Inability to control production resulted in the actual collapse of OPEC as a cartel capable of controlling production and therefore, oil prices. Long term economic forces have brought an equilibrium to the supply and demand of oil.	Oil prices will stay in the $ 10-15 a barrel range (in constant 1986 prices). No shortages of oil will develop. OPEC's share in the year 2000 will drop to 15%	
1987	Oil prices have been fluctuating around 17$.	OPEC countries have been observing a production limit and most non-OPEC countries go along. Saudi Arabia is cutting its production when supply exceeds demand.	Author's forecast: At present oil is overpriced by $4-8 a barrel (depending upo estimate). Once this has been corrected oil prices will, in the long run, follow inflation. If demand for oil increases more than average, oil prices will increase more than inflation in the short and medium term. When efficient engine and/or new energy sources are discovered oil prices will decrease in the long run below inflation.	

Exhibit 5: Ranking of five methods at different forecasting horizons



Serie : MNC44

S = Single Exponential Smoothing, D = Dampen Trend Exponential Smoothing, H = Holt's Exponential Smoothing, L = Linear Trend bases Regression, and B = Brown's Quadratic Exponential Smoothing

Exhibit 6: A monthly series (MNM61) of the M-Competition (with an unexpected pattern change while forecasting) and the forecasts of eight methods.

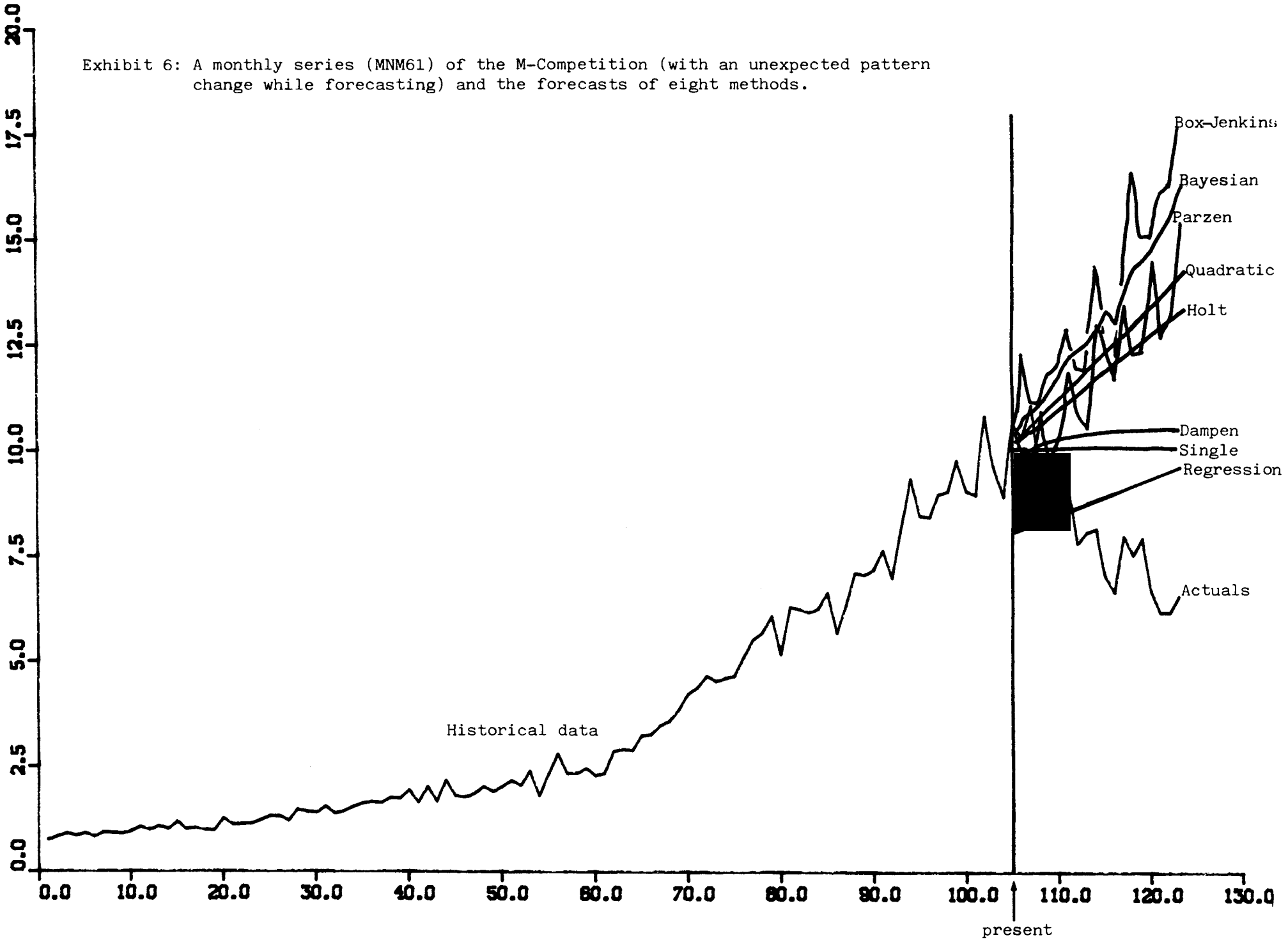


Exhibit 7: A quarterly series (QND37) of the M-Competition (with a pattern change just before forecasting) and the predictions of eight methods.

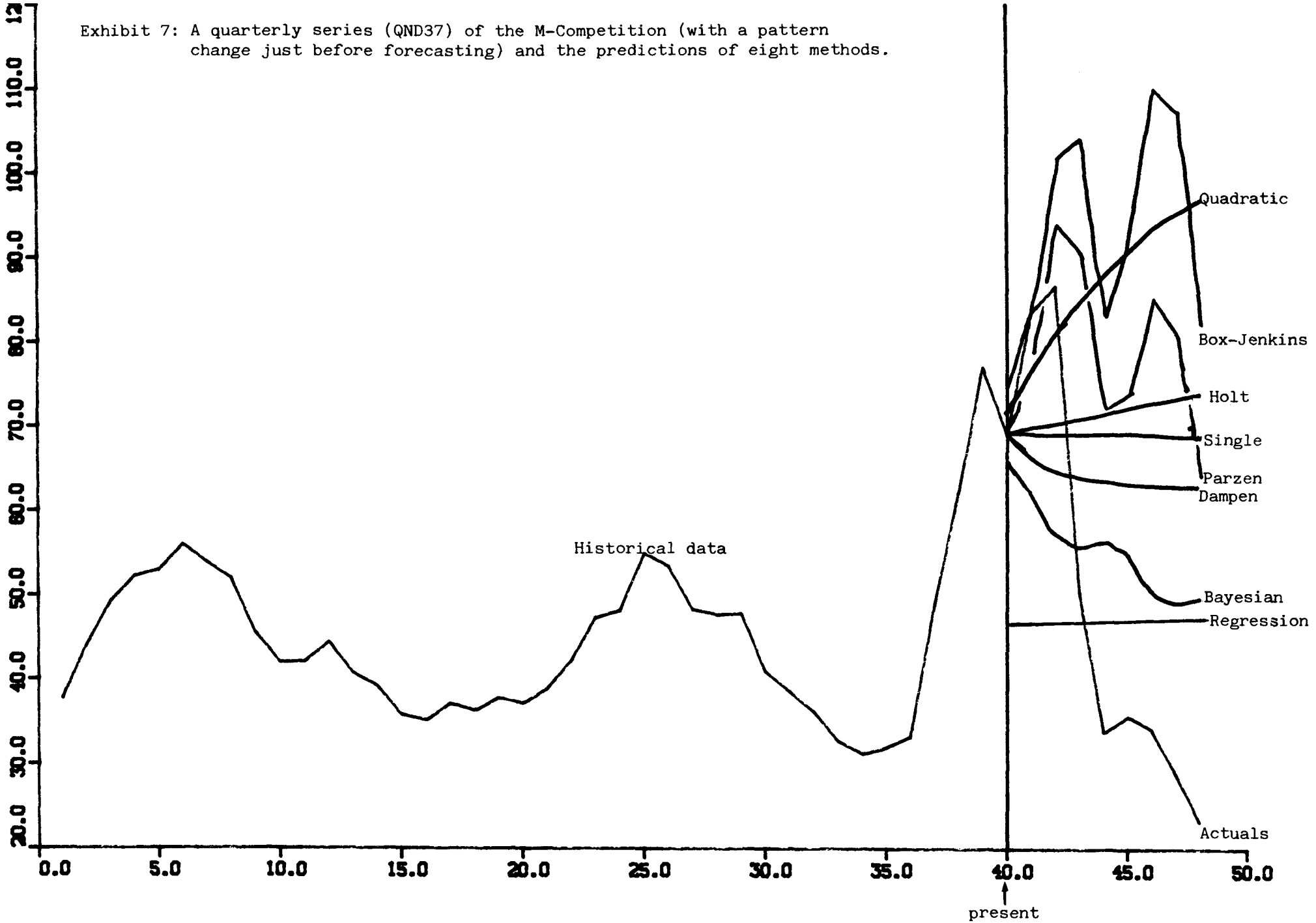


Exhibit 8: Areas/Aspects that Can and Cannot be Forecasted and Implications Involved

Time Horizon of Forecasting	Major areas/aspects that can be forecasted with a reasonable degree of accuracy	Major benefits from accurate forecasting	Major sources of surprise or unexpected forecasting errors	Problems/difficulties caused by surprises and unexpected forecasting errors	Typical mistakes (found through the empirical evaluation of past forecasts) that caused surprises and unexpected errors	Improving the forecasting process and the utilization of forecasts
Short Term (less than 3 months)	. Seasonality in sales . Promotional and advertising actions . Required level of inventories . Impact of price changes . Cash inflows and outflows . Raw and other material requirements . Workforce, personnel needs	. Improved customer satisfaction . Better production and/or service scheduling . Fewer inventories . More effective advertising/promotion policies . More effective pricing policies . More profitable cash management . Better material and personnel management	. Unexpected events (e.g., a fire, a major machine breakdown) . Special events (e.g., a big snowstorm, a strike) . Special competitive actions (e.g., an advertising campaign or a price decrease by a competitor) . Sales of new products	. High inventories . Under utilized workforce . Lost sales, loss of market share . Liquidity squeeze . Opportunity losses . Decreased profits or losses	. Inconsistency while forecasting . Unreserved optimism . Underestimating effects of uncertainty . Ignoring possible occurance of unexpected or unusual events . Ignoring influence of special events/actions	. Systematization and making objective the forecasting process . Keeping track of forecasting errors to determine systematic deviation . Becoming prepared to deal, if necessary, with unusual events . Taking into consideration the possibility of special actions . Recording effects of special events/actions to improve forecasting of future similar cases
Medium Term (3 months to 2 years)	. Established trends/patterns . Average length of recovery and expansion of business cycle . Average length of recession . Length of a recession . Average number of months between a change in the index of leading indicators and a change in the level of economic activity . The theoretical effects of fiscal/monetary policies on the economy . Estimation of existing relationships	. Better financial management . Improved allocation of resources . Reduced levels of inventories . Improved profits or reduced losses . Better competitive position	. Booms continued longer than average or longer than expected . Recessions started shorter than average or unexpected . Business climate and consumer attitudes were different than expected . Changes in relationships . Sales of new products	. Underutilization of personnel . High inventories . Lost sales . Lost market share . Serious financial problems . Opportunity losses . Decreased profits or losses . Decreased in long term competitive position	. Forgetting that booms or recessions do not last forever . Undue optimism and unwillingness to consider undesirable situations . Overpessimism during periods of bad economic or business conditions . Underestimating uncertainty	. Maintaining adequate liquidity . Understanding and taking into account the fact that economic/business conditions are cyclical . Accepting that recessions cannot be predicted . Creating a recession fund . Building adequate financial flexibility . Diversifying in non-cyclical industries . Better monitoring of economic/business conditions
LONG TERM: Emerging (2 years to 5 years)	. Established trends . Technological changes and their implications . Changes in attitudes and their implications . Demographic changes and their implications . Economic and political realities . Competitive realities . Financial resources and requirements	. More effective strategy formulation . Introducing changes in the organization . Identifying promising areas for capital investments, realizing, however, that competitors might have access to similarly accurate forecasts . Promising R & D projects . Improve (or maintain) competitive position	. Underestimating effects of emerging technologies and their implications on organizations or society . Unwillingness to consider flattening or negative trends . Unwillingness to accept effects of possible major environmental changes . Assuming that fads will continue	. Inability to introduce change . Inability to harness advantages of new technologies . Inability to deal with major environmental changes . Loss of competitive advantages . Losses from getting involved in fads whose demand dries out . Opportunity losses	. Ignoring obvious changes . Believing the effects of change to come much later . Conservatism . Overoptimism . Thinking that competitive advantages (and other barriers to entry) are adequate to guard against competition . Underestimating uncertainty . Being overdazzled by technological discoveries and their profit making potentials	. Having financial flexibility . Identification of major emerging technologies and their influence . Effective strategy that accepts and can deal with the uncertainty in long term forecasting . Considering the effects of environmental change on the fundamentals (customers, markets, products, competition, prices) . Identifying major problems/opportunities in the future
LONG TERM: Distant (5 years to 15 years)	. Established trends . Some technological innovations . Some demographic changes . Basic economic, competitive, and financial realities	. Building consensus . Initiation of feasibility studies for promising R & D projects . Establishing strategic directions	. Overestimating applicability of new technologies (e.g., nuclear power, artificial intelligence) . Overemphasizing ability of forecasting new technologies and their impact or usefulness	. Losses from getting involved in unsuccessful projects involving untested technologies or projects	. Automatically accepting economic advantages and ability of new technologies . Believing that the time between a discovery and its practical utilization to be short, and easy . Accept that barriers to entry, cartels, oligopolies, and monopolies can protect status quo	. Maintaining financial strength . Dynamic and flexible objectives . Evolving strategy . Considering economic advantage of new technologies (do not be dazzled by advocated technological wonders) . Spreading risks
LONG TERM: Far Away (15 years or more)	. Established trends . General tendancies in: . technology . Societal attitudes . economic environment . demography . political environment . competition	. General strategic directions	. Inability to forecast major technological innovations and their impact on business/society (e.g., growth and importance of computers)	. Wasting resources to make forecasts whose usefulness is dubious	. Unwillingness to accept that the future can be different to the past . Unwillingness to understand that radically new technologies, nobody envisions today, are possible in the future	. Better understanding the future and the forces that shape it . Being flexible to deal with a radically changing environment . Being willing to accept future uncertainty and take calculated risks

Exhibit 9: A Forecasting simulation of six forecasts using the Jack-knife approach.

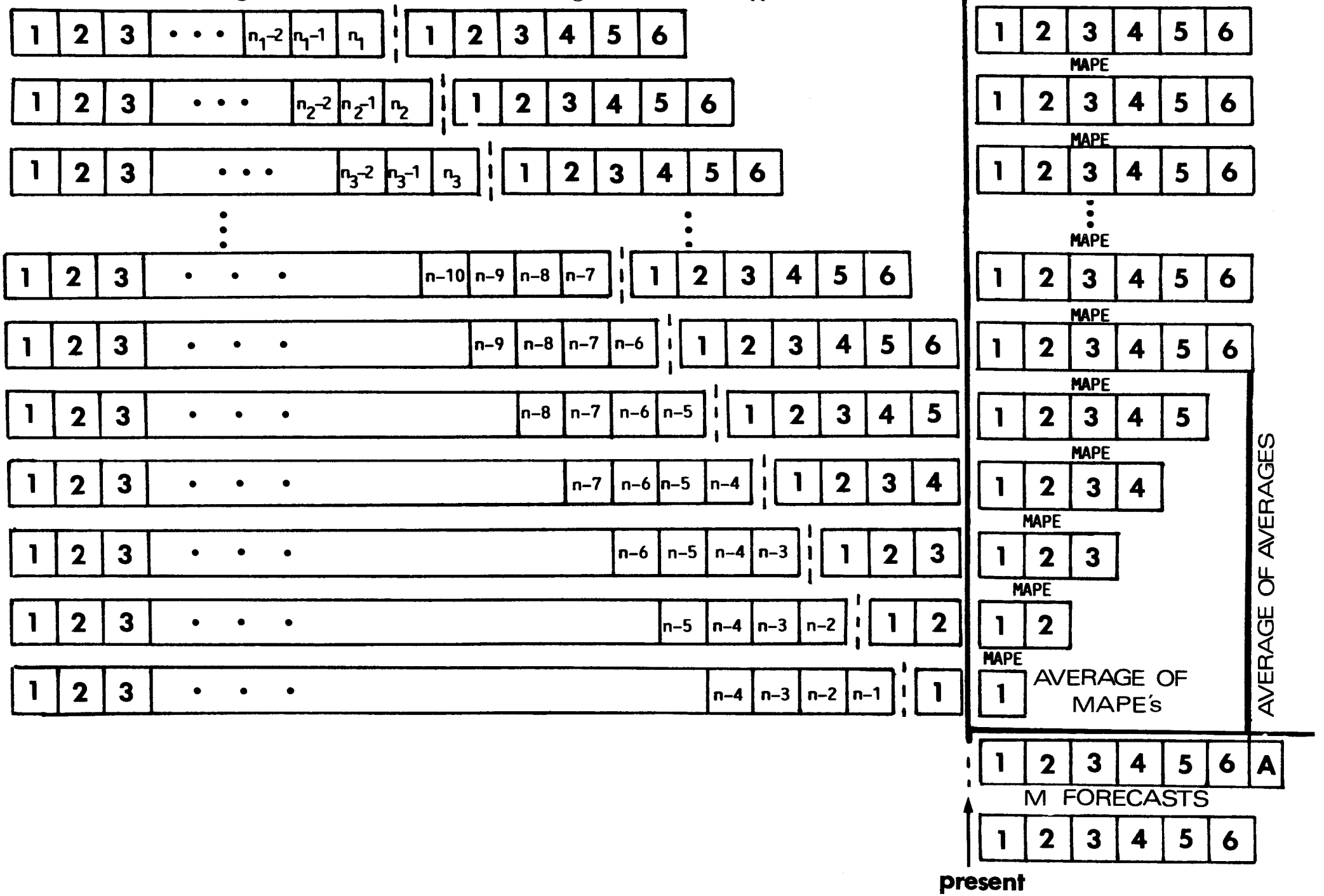


Exhibit 10: Advantages/Disadvantages of

STATISTICAL METHODS
VERSUS
JUDGMENTAL FORECASTS

	STATISTICAL METHODS	JUDGMENTAL FORECASTS
CHANGES IN ESTABLISHED PATTERNS AND/OR RELATIONSHIPS	CANNOT BE PREDICTED	COULD BE PREDICTED BUT CAN ALSO BE IGNORED OR PEOPLE CAN OVER-REACT TO THEM
UTILIZING AVAILABLE INFORMATION/ DATA	NOT ALL INFOR-MATION IN PAST DATA IS USED	PEOPLE ARE SELECTIVE, BIASED & INCONSISTENT
OBJECTIVITY	BASED ON SOME SPECIFIC SELECTION CRITERION/ CRITERIA	DEPENDS UPON PERSONAL & POLITICAL CONSIDERATIONS, & UNDUE OPTIMISM PESSIMISM
UNCERTAINTY	GROSSLY UNDERESTIMATED	GROSSLY UNDERESTIMATED MOSTLY ON THE OPTIMISTIC SIDE
COST	CHEAP TO USE	EXPENSIVE TO USE

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