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A Comparative Study of Methods for Long-Range Market Forecasting

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Abstract

The following hypotheses about long-range market forecasting were examined:

Hl Objective methods provide more accuracy than do subjective methods.

H2 The relative advantage of objective over subjective methods increases as the amount of change in the environment increases.

H3 Causal methods provide more accuracy than do naive methods.

H4 The relative advantage of causal over naive methods increases as the amount of change in the environment increases.

Support for these hypotheses was then obtained from the literature and from a study of a single market. The study used three different models to make ex ante forecasts of the U.S. air travel market from 1963 through 1968.

These hypotheses imply that econometric methods are more accurate for long range market forecasting than are the major alternatives, expert judgment and extrapolation, and that the relative superiority of econometric methods increases as the time span of the forecast increases.

Despite frequent claims that econometric methods will provide superior long-range forecasts, most firms still rely upon other approaches such as executive opinion or extrapolation methods (Pokemner and Bailey, 1970). This paper examines the relative accuracy of commonly used methods for long-range market forecasting. Are the claims of the econometricians justified?

The plan of the paper is as follows: a discussion is provided on possible methods by which one might obtain long-range forecasts (more than one year in the future). Some hypotheses are then presented which relate these methods to forecast accuracy and previous evidence on these hypotheses is briefly summarized. Finally, the hypotheses are tested in a study of the U.S. air travel market.

Methods for Long-Range Market Forecasting

There are many different ways in which to describe the methods used in developing long-range market forecasting models. This paper examines two aspects. The first deals with the method used to analyze the data and is labeled the "subjective-objective" dimension. The second deals with the type of information and is labeled the "naive-causal" dimension.

Subjective vs. Objective Methods

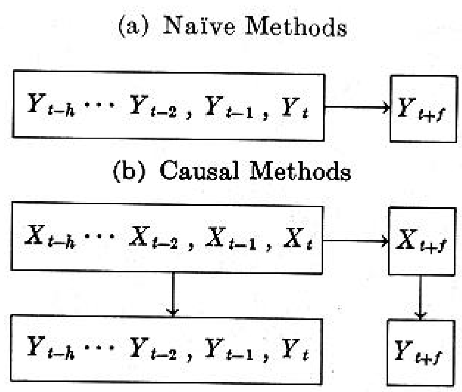
Subjective (or judgmental or intuitive or implicit) methods are those in which the process used to obtain the forecasts has not been well specified. The process is carried out "in the head" of the forecaster. Subjective methods are widely used in forecasting by managers, psychiatrists, medical doctors, sociologists, political scientists, etc.

Objective methods are those in which the process used to obtain the forecasts has been well specified. In the extreme, it has been specified so well that other researchers can replicate the method and obtain the same forecasts. Objective methods lend themselves well to computer processing.

Naïve vs. Causal Methods

Naive methods are those which use data on only the dependent variable (e.g., a measure of sales). Typically, an analysis is carried out to see whether the dependent variable shows any regularities over time. The time pattern is then projected into the future as shown in Exhibit 1(a).

Exhibit 1
Naïve vs. Causal Methods



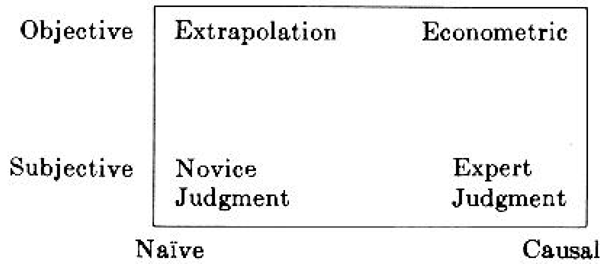
Key:
Y is the dependent variable,
X is the set of causal variables,
h is the number of years of historical data,
f is the number of years in the future,
t is the present year.

Causal methods go beyond the dependent variable to consider also variables which may cause changes in the dependent variable. An attempt is made to determine what causal variables are important, then to forecast the causal variables, and, finally, to infer values for the dependent variable on the basis of the changes in the causal variables. This process is outlined in Exhibit 1(b). The key assumptions are that the causal variables can be measured and projected rather accurately in comparison to a projection of the dependent variable and that the relationships will remain constant over time.

Some Theoretical Types of Forecasting Methods

Each of the dimensions, causal-naive and subjective-objective, may be thought of as a continuum. By examining the extreme points of these continua, one can conceive of four theoretical types of methods. We have labeled these four types as novice judgment (subjective-naive), extrapolation (objective-naive), expert judgment (subjective-causal) and econometric (objective-causal). The relationship between these methods and the two basic dimensions is illustrated in Exhibit 2.

Exhibit 2
Some Theoretical Types of Forecasting Methods



This paper examines the extrapolation, econometric and expert judgment methods. The novice judgment method has been excluded since it was not expected to be a strong candidate in this situation and since, at the time of the study, it would be difficult to find people who knew nothing at all about what happened in the air travel market from 1963 through 1968.

The primary interest in the paper is in trying to compare the various types of methods. It is quite likely that *combination* of forecasts from different methods could lead to still further improvements, but this possibility was not investigated here.

Hypotheses Relating Forecast Methods to Accuracy

The change in the environment is hypothesized to be of particular importance in deciding on the most accurate method. By "change in the environment," we mean the departure from the normal pattern of events. Using the basic dimensions of Exhibit 2 and the notion that change is important, four hypotheses were proposed which relate to forecast accuracy:

Hl In general, objective methods will lead to more accurate long-range market forecasts than do subjective methods.

H2 Objective methods tend to be relatively more accurate than subjective methods as the change in the environment increases.

H3 In general, causal methods will lead to more accurate long-range market forecasts than do naive methods.

H4 Causal methods tend to be relatively more accurate than naive methods as the change in the environment increases.

For this study, "change in the environment" will be measured by the length of the forecast horizon. In other words, as the time span increases, it is more likely that large changes will occur in the environment.

Previous Research

A brief review is provided here of some of the evidence which bears on the above hypotheses. We were interested primarily in studies which compared alternative methods, which provided unconditional forecasts, and which related to long-range market forecasting. The latter criterion was relaxed somewhat in our effort to find previous research studies.

Hl *Objective methods more accurate than subjective methods.* Cragg and Malkiel (1968), in a study of the earnings growth in a sample of U.S. corporations, compared forecasts by securities analysts with simple extrapolations. There was little difference in the errors for either a 2- or 3-year forecast horizon.

Some work has been done on the comparison of methods for one-year economy-wide forecasting (e.g. Zarnowitz, 1967, and Kosobud, 1970). This work indicates that objective methods (econometric models in this case) tend to be more accurate than subjective methods (forecasts by business economists).

H2 *Accuracy of objective vs. subjective methods increases as change in the environment increases.* Mincer and Zarnowitz (1969) found that the relative accuracy of objective (extrapolation) methods tended to improve relative to judgment methods as the time span increased from 1 to 4 quarters in forecasts of GNP and of industrial production in the U.S.

H3 *Causal methods more accurate than naive methods.* Numerous authors have implied that causal methods are more accurate than naive methods (e.g., Spencer et al. 1961). Armstrong (1968) found support for this hypothesis in a study of the international market for still cameras. O'Herlihy (1967) also found convincing support in five-year forecasts of cars, selected consumer durables and energy in Great Britain. Ogburn (1946) found modest support in a ten-year forecast of the U.S. air travel market. Also, the work on one-year forecasts of GNP provides some support (e.g. Kosobud, 1970, and Moore, 1969, for recent evidence).

H4 *Accuracy of causal vs. naive methods increases as change in the environment increases.* This hypothesis does not have as much face validity as we initially thought, since Herman Wold has suggested just the opposite hypothesis (NATO, 1967, p. 48). In our opinion, the causal method should be superior since it makes an explicit attempt to account for the effects of the changes. The results from Mincer and Zarnowitz (1969) tend to favor Wold's hypothesis rather than ours.

Testing the Hypotheses in the U.S. Air Travel Market

As may be noted above, we were unable to find much evidence to support (or refute) the four hypotheses. An attempt was made to obtain further evidence by directly testing these hypotheses in a study of the U.S. domestic air travel market.

Three different models were developed to forecast revenue passenger miles in the U.S.; one model was based on extrapolation (objective-naive) methods, another on expert judgment (subjective-causal) methods, and the third on econometric (objective-causal) methods. Unconditional or ex ante forecasts were compared with actual data to provide measures of accuracy.[1] Finally, the accuracy of each model was used in testing the four hypotheses.

A brief description of each of the three models is presented below in order to highlight the differences in methods.

The Expert Judgment Model

The expert judgment model was developed by the Federal Aviation Administration (FAA). Due to the subjective nature of this approach, it is very difficult to find an adequate description of how the forecasts were made. On the basis of the descriptions in the FAA's annual *Aviation Forecasts* and from communications with people at the FAA, it appears that the forecasts were developed by examining past trends in revenue passenger miles and then revising these trends in the light of the expected effects due to changes in real GNP, population, domestic air fares and other factors. The analysis of this information to yield forecasts was rather subjective. It was carried out by people who had had a significant amount of experience in the industry and who also had much data at their disposal. Overall, the method appears to be a good representation of the expert judgment method presented in Exhibit 2 (i.e., the lower right-hand corner).

[1] The forecasts were not "ex ante" in the strictest sense of the term since the events had, in fact, already occurred. As the authors are not experts in the air travel market, it was not expected that information from later than 1962 would seriously contaminate the subjective portions of the econometric model.

The Extrapolation Model

An extrapolation model was desired which was simple and also was commonly used in forecasting. We used a model which assumed a constant percentage growth rate. The growth rate for any one point in time was calculated from the experience of the most recent ten years. Thus, the forecasts made in 1962 used the growth rate from 1952 to 1962; those made in 1963 used 1953 to 1963, etc. This model is based on the extrapolation method of Exhibit 2 (i.e., the extreme upper left-hand corner).

The Econometric Model

We developed an econometric model of the U.S. air travel market. The details of this model are not important to our argument, since we feel that the application of standard econometric methods would have led to similar results. Therefore, only a brief summary of our model is presented here.[2]

Our approach to the development of econometric methods was rather typical of standard practice except that a heavier emphasis was placed upon the a priori (subjective) analysis. Ordinary least squares (i.e., the standard single equation regression analysis) was then used to update the parameters of the model. We refer to this approach as a "poor man's Bayesian regression analysis." It is sometimes referred to as "conditional regression analysis" (see Wold and Jureen, 1953).

This poor man's Bayesian analysis was basically as follows: After developing the a priori version of the model, the independent variables (price, speed, income and safety) were regressed against revenue passenger miles *per capita*. On the basis of some trial and error using the prior estimates, different amounts of data (some data were available for as far back as 1926) and different combinations of variables, decisions were made as to the "best" estimates for the speed, income, and safety coefficients. The updated version of the forecasting model is presented in Exhibit 3. Only the estimates for the price elasticity and the constant term were derived solely from the time series data.

Exhibit 3
Air Travel Forecasting Model: Updated with 1938-1962 Data

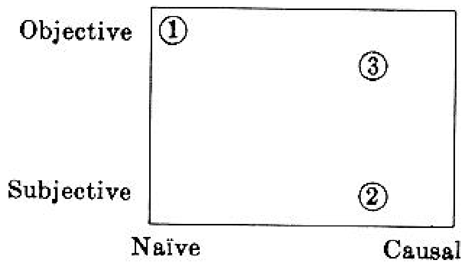
$$M_{t+f} = (1.12)^f M_t \left(\frac{P_{t+f}}{P_t}\right)^{-1.2} \left(\frac{S_{t+f}}{S_t}\right)^{0.2} \left(\frac{I_{t+f}}{I_t}\right)^{0.5} \left(\frac{N_{t+f}}{N_t}\right)^{1.0} \left(\frac{D_{t+f}}{D_t}\right)^{-0.05}$$

where:
- t designates the current year,
- f is the number of years in the future,
- M is U.S. domestic revenue passenger miles,
- P is price of air travel (cents per revenue passenger mile in constant dollars),
- S is average airborne speed (miles per hour),
- I is a measure of income (GNP per capita in constant dollars),
- N is U.S. population,
- D is the death rate per 100 million revenue passenger miles.

The above econometric model represents a combination of subjective methods followed by objective methods. We feel that this procedure is representative of much applied work in econometrics; it only approaches the causal-objective extreme as roughly illustrated in Exhibit 4. The judgment and extrapolation models for this study are also illustrated.

[2] Further details on the development of our econometric model may, however, be obtained from the senior author.

Exhibit 4
Actual vs. Theoretical Methods in U.S. Air Travel Study



Key:
1 is the constant percentage change or extrapolation model,
2 is the FAA judgment model,
3 is the Armstrong-Grohman econometric model.

Making the Unconditional Forecasts for 1963 Through 1968

The judgment model forecasts were made by the FAA and are reported in their annual, *Aviation Forecasts.* In order to allow for comparisons to be made among the models, it was necessary to change the FAA forecasts from a fiscal year basis (starting July 1) to a calendar year basis. This was done by using simple liner interpolations, e.g., the forecast for July 1, 1963 to June 30, 1964 and that. for July 1, 1964 to June 30, 1965 were averaged to give a forecast of the 1964 calendar year.

The forecasts for the extrapolation model were straightforward. The percentage growth rate of the most recent ten years was used.

The econometric model forecasts were more complex. Forecasts were first required for the change in each of the causal variables, i.e., for price, speed, income and population (no change was anticipated in the safety variable). An extrapolation model was used to make these forecasts. This extrapolation model was identical to the one described above for forecasting sales-the percentage growth rate from the previous ten years was used to make the forecasts. (This was a rather crude approach, and one might expect that the extensive efforts which go into forecasts of GNP and of population could have led to minor improvements in accuracy.) Given the forecasts of the causal variables, it was then a simple matter to calculate sales using the econometric model presented in Exhibit 3.

Finally, 1962 was used as a base, and yearly forecasts were made for 1963 through 1968. Actual data were then incorporated from 1963, and yearly forecasts were then made for 1964 through 1968. This process was repeated until the actual data for 1967 had been used. (No updating was carried out for the *parameters* of the econometric model during this time. Again, such a refinement would be expected to lead to minor improvements in accuracy.)

Measuring Forecast Accuracy

The forecasts from each of the three models were then compared with actual data. The percentage error was calculated for each forecast by taking the difference between the forecast and actual values and dividing this by the actual value. It was then assumed that overestimates (i.e., forecast greater than actual, which could lead to excess capacity) were as serious as underestimates (i.e., forecast less than actual, implying an opportunity cost). This assumption allowed us to focus upon the absolute value of the percentage error.

Exhibit 5 presents a summary of the accuracy of each model. Overall, the forecast error in the econometric model was less than that in the extrapolation model which, in turn, was less than that in the judgment model.

Exhibit 5
Accuracy of the Different Methods of Forecasting the U.S. Air Travel Marketing During 1963-1968
(All Domestic Carriers)

Forecast Horizon in Years	Number of Different Forecasts	Mean Absolute Percentage Error*		
		Extrapolation	Judgment	Econometric
1	6	5.7	6.8	4.2
2	5	12.7	15.6	6.8
3	4	17.4	25.1	7.3
4	3	22.5	34.1	9.8
5	2	27.5	42.1	6.2
6	1	29.9	45.0**	0.7
Total	21			
Averages		19.3	28.1	5.8

* In nearly all cases, the forecasts were lower than actual.
** Based on a 5- rather than a 6-year horizon.

Hypothesis Testing

Hl. To test whether objective methods provide more accurate forecasts than subjective methods, the accuracy of the econometric (objective-causal) and expert judgment (subjective-causal) models were compared. The percentage error from the econometrical model was about one-fifth that from the expert judgment model (5.8 vs. 28.1). This margin of superiority would seem to be of some practical significance.

The possibility that the difference in accuracy between the two models was due to chance was tested by means of the Wilcoxon matched-pairs signed-ranks test (Siegel, 1956).[3] The null hypothesis that there was no difference between the 21 pairs of forecasts was rejected at the 0.01 level of significance. This provides support for H, .

H2. To test whether objective methods tend to be relatively more accurate than subjective methods as the change in the environment increases, an examination was made of the expert judgment and econometric models as the forecast horizon was lengthened. Assuming, as it seemed reasonable, that the environment changes more in the long run than in the short run, the error for the econometric model should decrease relative to that for the expert judgment model as the forecast horizon increases. The results for this test are presented in Exhibit 6.

Exhibit 6
Relative Accuracy of Objective vs. Subjective Methods

Forecast Horizon in Years	Absolute Value of Judgment Minus Econometric Error	Ratio of Econometric Error to Judgment Error
1	2.6	0.62
2	8.8	0.44
3	17.8	0.29^{+}
4	24.3	0.29^{-}
5	35.9	0.15
6	43.3	0.02

[3] This test is almost as powerful as the t-test yet it makes few assumptions about the data. Of particular interest to this study was the fact that the test is not affected by outliers.

The ranking of the absolute value of the difference in errors is in perfect agreement with the hypothesis and is statistically significant at the 0.01 level (one-tail test) using the Spearman rank correlation coefficient (Siegel, 1956). The ranking of the ratio of the differences, an alternative and more stringent criterion, is also in perfect agreement with the hypothesis. These results, then, provided support for H2 .

H3. To test whether causal methods lead to more accurate forecasts than do naive methods, the econometric (objective-causal) and extrapolation (objective-naive) models were compared. The average percentage error of the econometric model was less than one-third that of the extrapolation model (5.8 vs. 19.3). The null hypothesis that there was no difference in accuracy was tested by using the Wilcoxon matched pairs signed-ranks test on the 21 pairs of forecasts. The null hypothesis was rejected at the 0.01 level, thus providing support for H3 .

H4. To test whether the relative value of the causal method increases as the change in the environment increases, the errors of the econometric and extrapolation models were compared as the forecast horizon was lengthened. The results are presented in Exhibit 7. The ranking of the absolute value of the differences in errors between the extrapolation and econometric model was in perfect agreement with the hypothesis (significant at 0.01 level by the Spearman rank correlation coefficient). The ranking of the ratios of the errors was not quite in perfect agreement with the hypothesis, yet the similarity is close enough so that the null hypothesis of "no agreement" was rejected at the 0.01 level. Thus, H4 was supported.

Exhibit 7
Relative Accuracy of Causal vs. Naïve Methods Over Time

Forecast Horizon in Years	Absolute Value of Extrapolation Minus Econometric Error	Ratio of Econometric Error to Extrapolation Error
1	1.5	0.74
2	5.9	0.54
3	10.1	0.24
4	12.7	0.44
5	21.3	0.22
6	29.2	0.02

Alternative Explanations

While the study provides support for all four hypotheses, it is important to consider some of the limitations of this study. Four possible limitations were examined-first, there may have been a "fortunate" selection of the econometric model; second, there may have been an unfortunate selection of the extrapolation model; third, there may have been an unfortunate selection of the expert judgment model; and, fourth, other reasonable criteria for accuracy may have led to different results.

Selection of the Econometric Model

Is it likely that the application of standard econometric techniques by other researchers would have led to similar results? This question is especially important in this study, since some stages in the development of the econometric model, most notably the estimation stage, involved subjective elements.

After our econometric model had been developed, an examination was carried out of an econometric model developed by another research team. The fact that our study was done completely *independently* of this other study allowed us to test the issue as to whether the "application of standard econometric techniques by other researchers would have led to similar results."[4]

The Civil Aeronautics Board (CAB) has been using an econometric model for some time (Saginor, 1967). Their most recent version of the model, which predicts revenue passenger miles for eleven domestic trunkline carriers (a measure which is quite Similar to that used in our study), was estimated on the basis of 1946 to 1966 data. Their model turned out to be surprisingly similar to ours. It used the same functional form (first differences of the logs). In addition, the causal variables were very similar population, average fare per passenger mile, real disposable income per capita and time. (Our econometric model differed in that it also used speed and safety, but did not use time.) The estimated elasticities of the CAB model were even similar to those found in our study.

The CAB model is presented in Exhibit 8. The symbols have been made to conform with those in Exhibit 3 to assist in comparison as there were only slight differences in the measurement of the variables.

Exhibit 8
CAB Model to Forecast the Air Travel Market (Based on 1946-1966 Data)

$$M_{t+f} = (1.18)^f M_t \left(\frac{P_{t+f}}{P_t}\right)^{-1.3} \left(\frac{I_{t+f}}{I_t}\right)^{1.1} \left(\frac{N_{t+f}}{N_t}\right)^{1.0} (T)^{-0.04}$$

our estimates (1.12) (−1.2) (0.5) (1.0) (0.0)

where

t designates the year,
f is the number of years in the future,
M is revenue passenger miles (eleven trunkline carriers),
P is price of air travel (cents per revenue passenger mile in constant dollars),
I is income (GNP per capita in constant dollars),
N is population,
T is time (1937 = 0; 38 = 1; etc.).

In sum, it seems that adherence to general econometric procedures has led two different research teams to develop rather similar models.

Saginor had also examined the forecasts made in 1959 using an earlier and somewhat different version of the CAB econometric model. For comparison, we developed an extrapolation model for the same time period. This extrapolation model was based on a constant percentage change per year and was estimated on data from 1950 up through 1959. The results from this comparison are presented in Exhibit 9.

[4] The usual procedure in estimation is to try to utilize all previous research in carrying out the a priori analysis. The notion of "saving" prior research was useful for hypothesis testing in this study. We feel that this might be a useful strategy for other econometric studies as well.

Exhibit 9
Accuracy of Different Methods in Forecasting the U.S. Air Travel Marketing during 1960-1965
(Domestic Trunk Carriers Only)

Forecast Horizon in Years	Number of Different Forecasts	Extrapolation Model Percentage Error	CAB Econometric Model Percentage Error	Absolute Value of Econometric minus Extrapolation Error	Ratio of Econometric to Extrapolation Error
		A	B	$\|A-B\|$	B/A
1	1	−7.5	−5.8	1.7	0.77
2	1	−21.4	−16.6	4.8	0.77
3	1	−29.3	−20.1	8.2	0.71
4	1	−27.7	−16.2	11.5	0.59
5	1	−29.6	−11.5	15.4	0.43
6	1	−23.1	−4.1	19.0	0.17
Mean Absolute Percentage Error		22.9	12.4		

The results from Exhibit 9 are in agreement with the hypotheses on the advantages of the causal over the naive model and on the relatively better performance of the causal model in the longer run.

Selection of *the Extrapolation Model*

Judging from Ogburn's (1946) results, the forecasts of the air travel market can be very sensitive to the choice of an extrapolation model. He used five different extrapolation models and obtained very different forecasts for 1953 (using data from up through 1943). It is possible, then, that the choice of a "better" extrapolation model would have led to significantly better results in our study.

The use of exponential smoothing methods would seem to offer some promise. (See Geoffrion, 1962, for a brief description of exponential smoothing.) This possibility was not, however, examined in this study.

One other extrapolation model was considered. This assumed a constant unit change and was estimated by a regression over the past ten years. The accuracy of this model proved to be markedly inferior to that of the constant percentage change model.

Selection of the Expert Judgment Model

Although the FAA is supposed to be a group of unbiased experts, it is quite apparent that regulatory bodies have difficulty in maintaining an unbiased position. The fact that the FAA forecasts were always very low seemed strange, and it is hard to imagine why they were so much poorer than those from a simple extrapolation. Advocates of certain expert judgment methods (such as Delphi) could make the argument that the method is capable of producing much more accurate forecasts than those provided by the FAA. We suggest, however, that the FAA method is *typical* of the expert judgment method as it is currently used in long-range market forecasting.

The Use of Other Criteria

The analysis for our three models was repeated using a different criterion. This criterion calculated the percentage error by using the average of the actual and forecasted miles as the base-in contrast to using actual miles as above.

Letting A = actual and P = predicted miles:

$$\frac{|A - P|}{(A + P)/2}$$

This criterion makes errors of scale symmetrical. For example, a forecast of one half of the actual would be just as good (or as bad) as a forecast which is twice actual.

The forecast error was 6.1 % for the Armstrong-Grohman model, 21.8 % for the extrapolation model and 33.6 % for the FAA model. These results are very close to those in Exhibit 5.

Consideration was also given to the average percentage error which *included* information about signs (i.e., absolute values were not used as above). This provides a measure of systematic error. Did the forecasts tend to be too high or too low over a number of years? All three models displayed large systematic errors-actual miles almost always exceeded forecast. The rapid decrease in fares and the rapid increase in personal income were probably responsible. Still, the superiority in the econometric model was evident. The average percentage errors for the econometric model of +4.4 vs. +19.3 for the extrapolation model and +28.1 for the judgment model were almost identical to the results in Exhibit 5. Again, none of the conclusions from above would be altered in the light of this criterion.

Conclusions

Four hypotheses were proposed about methods for long-range forecasting. These suggested that objective methods are more accurate than subjective methods; that causal methods are more accurate than naive methods; and that the superiority of objective and causal methods increases as the "amount of change" in the environment increases. Prior evidence on these hypotheses was not strong. However, they did receive rather strong support from a study of the U.S. air travel market.

The implications are that existing econometric methods would seem to offer more accurate long-range forecasts than may be obtained from other commonly used methods-namely, expert judgment and extrapolation methods. The accuracy of the econometric method *relative to these other* methods increases as the time horizon of the forecast increases. In short, it is suggested that firms are likely to obtain more accurate long-range forecasts if they use econometric methods.

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