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A COMPARATIVE ANALYSIS OF THREE MACRO PRICE FORECASTING SYSTEMS

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ABSTRACT

This paper examines the relative performance of three different systems of forecasting movements in macro building prices. The three systems analysed are (1) the Building Cost Information Service system, (2) the Davis, Langdon & Everest system, and (3) Akintoye and Skitmore's reduced-form simultaneous equation. A battery of accuracy measures are used to compare the forecasts published by the Building Cost Information Service and Davis, Langdon & Everest systems and simulated out-sample forecasts made by the Akintoye and Skitmore system. The results indicate that, during the three year period commencing with the first quarter 1988, the Akintoye and Skitmore system gives the most accurate forecasts for a zero to three quarters forecast horizon and the Building Cost Information Service system gives the most accurate forecasts for a four to eight quarters forecast horizon.

Keywords: Tender Price Index, forecasting, econometrics, accuracy.

INTRODUCTION

A major objective of construction management and economics research is to improve the quality of decision making in the industry. One way of achieving this is to find means of improving the quality of information available to decision makers concerning the likely outcomes of potential decisions. For economic and investment decisions, forecasts are needed of future price levels. Macro price forecasts are currently available in the form of a tender price index (TPI) from several systems. Little is known of the forecasting accuracy of these systems or of the impact of economic circumstances on this accuracy to enable decision makers to fully appreciate each systems limitations or select one to use.

This paper describes an analysis of the reliability and forecasting behaviour of three of these systems - (1) The Royal Institution of Chartered Surveyors' Building Cost Information Services's (BCIS) system, (2) the Davis, Langdon & Everest (DL&E) system, and (3) Akintoye and Skitmore's (1993) reduced-form simultaneous equation (A&S). The BCIS and DL&E systems were chosen for comparison purposes because: apart from the Property Services Agency Specialist Services (Directorate of Building Surveying Services) these are the two most established organisations in forecasting construction price movements, with activities dating back to 1980 and 1976 respectively; and both are private sector organisations and both forecast movements in tender price relating to both public and private construction work. The tender price forecasts of these two organisations should therefore be a good reflection of the genuine competitive situation in the construction industry.

The A&S equation is one of two recently developed econometric models of macro building prices. In their paper, Akintoye and Skitmore (1993) present a reduced form simultaneous equation model to explain general movements and a single structural equation model, based on economic theory, to explain structural TPI movements. Both models were found to fit the BCIS TPI well. Single structural models however are known to have an inferior predictive power to reduced-form equations (Kane, 1968:21-2; Neal and Shone 1976) and therefore the reduced-form equation has been adopted in this analysis.

A battery of accuracy measures is described and these are applied to the forecasts provided by the systems for comparative purposes. For the period examined, the results indicate that the Akintoye and Skitmore system gives the most accurate forecasts for a zero to three quarters forecast horizon and the Building Cost Information Service system gives the most accurate forecasts for a four to eight quarters forecast horizon.

MODELS, FORECASTING AND ERRORS

Models

Economic models may be used for two purposes, firstly to **explain** past events and secondly to **forecast** future events. Forecasting systems can be purely judgemental or intuitive, rely on causal or explanatory methods (regression or econometric models), use time series (extrapolative) methods or a combination of such methods (Makridakis, 1984). These forecasting methods can be classified into either qualitative forecasting methods - judgemental or intuitive approaches that generally use the opinions of experts to predict future events - or quantitative forecasting methods - involving numerical analysis of historical data to predict future values of relevant variables.

Purely quantitative, or mechanically generated, forecasts assume complete and stable information concerning the model (McNees, 1985) and, as a result, most published forecasts of macroeconomic variables contain some judgemental adjustment (McNees and Ries, 1983). Whether such a procedure provides the best forecasts is a debatable issue (eg., Evans *et al,* 1972; Haitovsky and Treyz, 1972; Kahneman and Tversky, 1982; Lucas, 1976; McNees, 1990; Sim, 1980), the art of forecasting involving a complex interaction between the model, the input assumptions and the forecaster's judgemental abilities (McNees, 1989). However, the accuracy of the forecast is a function of the combined effects of the irregular component in the model and the accuracy with which trends and seasonal or cyclical patterns can be predicted in advance (Bowerman and O'Connel, 1987).

The level of accuracy achieved by a forecast depends primarily on a combination of its intended use, forecast form (point or prediction interval forecast), time horizon and availability of data (O'Donovan, 1983; Bowerman and O'Connel, 1987). For example, it is generally found that the accuracy of a forecast of a given time span generally decreases as the horizon of the forecast increases (McNees and Ries, 1983); the predictive value of forecasts more than a few quarters into the future diminishes quite rapidly (Zarnowitz, 1979).

The value of such economic forecast data for economic decisions depends upon both their reliability and their timeliness (McNees, 1986). For example, project price forecasts are known to have an error standard deviation of around 15 to 20 percent in the early stages of design reducing to around 13 to 18 percent in the later stages of design (Ashworth & Skitmore, 1983). These accuracy levels are achieved having defined the intended use, time horizon and a prediction interval forecast form.

In model building and testing, accuracy can be assessed in three ways; by *ex post* simulation or "historical" simulation in which the values of dependent variables are simulated over the period in which the model was estimated, that is the in-sample period; by *ex post* forecasting, in which the model is simulated beyond the estimation period, but not further than the last date for which the data is available; and by *ex ante* forecasting, by which forecasts are made beyond the last date for which data is available (Pindyck and Rubinfeld, 1976:313). These three periods are illustrated in Fig 1. *Ex post* and *ex ante* forecasts are both regarded as out-of-sample period forecasts. In *ex post* simulation, a comparison can be made between the actual values and predicted values of the dependent variable to determine forecasting accuracy. Most often the best model forecast fit comes from the *ex post* simulation period, followed by the *ex post* forecast period, with the poorest fit coming from the *ex ante* forecast period (Dhrymes *et al*, 1972, have shown that in the single equation case, the root mean squared error of the post-sample period should be expected to exceed the standard error of the fitted equation).

Accuracy can be measured in terms of bias (the difference between the average levels of actual and forecast values) or consistency (the dispersion of actual and forecast values around the average). The most common measures are non-parametric and comprise the mean square error (MSE), Theil's *U*-coefficient (Theil, 1966) and the mean absolute percentage error (MAPE) (Makridakis and Hibon, 1984). Other measures of accuracy (Holden and Peel, 1988; Trehan, 1989) include root mean square error (RMSE), mean error (ME), mean percentage error (MPE) and mean absolute error (MAE). Graphical representation may also be used to provide a visual observation of accuracy.

The mean square error can be decomposed into several sets of statistics such that the sources of forecast errors can be identified (Theil, 1966). This may then enable an optimal linear correction to be made, by regressing actual values on predicted values and using the resultant estimated coefficients as correction factors in the model.

THE BCIS SYSTEM

The BCIS is a self financing non-profit making organisation with two main objectives: "(1) to provide for cost information needs of the Quantity Surveying Division of The Royal Institution of Chartered Surveyors (RICS) and (2) to assist in confirming the Chartered Quantity Surveyor's pre-eminence in the field of building economics and cost advice and make this expertise and status more generally known" (BCIS, 1987).

The BCIS has been involved in monitoring building prices since 1961. Cost analyses were published in the first BCIS bulletins in May 1962. However, it was not until June 1980 that the first "24-month forecast of tender price index" was published, in the form of a point forecast.

Forecasting system[1]

The BCIS use a linear regression model to provide TPI forecasts, this was as a result of research into computer-aided tender price prediction in the late 1970's by McCaffer and McCaffrey at Loughborough University. The input variables of the BCIS TPI forecasting model comprise; the building cost index; the amount of construction output; and the amount of construction new orders. Of these variables, the building cost index makes only a small contribution whilst the amount of new orders makes the largest contribution. The implication of course is that changes in construction prices are related more to changes in market forces, and especially demand pull, than changes in input costs.

The forecasts resulting from the BCIS models are substantially adjusted by the BCIS's experts' judgement. Though BCIS claims to monitor the accuracy of its published forecasts, it is not sure of the impact of the judgemental adjustment on the accuracy of the published forecast. The factors the BCIS have identified as responsible for problems in forecasting TPI include the unpredictable reaction of contractors to changes in construction demand.

Forecast accuracy

[1] The information in this section was obtained directly from BCIS (Martin, 1981).

Earlier studies involving the non-parametric analysis of TPI forecast accuracy have been reported by McCaffer *et al* (1983) and Fellows (1988). Fellows (1988) calculated the BCIS mean percentage forecast errors of the all-in TPI using published forecasts between June 1980 and November 1983. This study also developed a TPI regression adjustment model excluding and including 1980 forecasts using the number of quarters forecast horizon as a variable. The Fellows' model, excluding 1980 forecasts, was found to perform better than the BCIS forecasts for the same period in 1984. As a result Fellows' concluded that, his model being based on only an 11 quarter series, forecasting accuracy might be improved by using a simpler model than the BCIS model, but based on a lengthier series.

In our analysis of the BCIS model work we first considered the forecast period covering the eleven years (thirty-nine quarters) from the second quarter 1980 (1980:2) through to the fourth quarter 1990 (1990:4), with a forecast horizon (quarters ahead) covering eight quarters (0, 1, ... , 8 quarters ahead). Thus, there are 43 zero-quarter-ahead forecasts, 42 one-quarter-ahead forecast, 41 two-quarter-ahead forecasts, and 35 eight-quarter-ahead forecasts. The 35 eight-quarter-ahead forecasts are long enough for the generalised long-term performance of TPI forecast model to be assessed.

The forecast accuracy of TPI was then investigated by both visual inspection of graphical information and non-parametric tests.

Graphical presentation

Fig 2 shows the plots of actual and the BCIS forecasted values of the TPI. The plots presented in the figure relate to values between 1982:1 and 1990:4 to allow for a standardized comparison of performances across the forecast horizon. The plots of the predicted values covers all of the eight quarter forecast horizon. The plots present a clear picture of the performance of the BCIS forecast of TPI. Visual observation of these plots shows that the forecasts of TPI generally track the actual levels up to the two quarter forecast horizon. The forecasts for more than the two quarter horizon are not very accurate and generally did not predict the actual turning points in price levels. The forecasts between 1988:4 and 1990:4 were significantly different from actual values even at the zero quarter horizon. This period coincided with a sporadic decline in the UK's economic fortune and consequently declining construction demand, presumably not anticipated by the BCIS 'experts'.

The frequency distribution of the MPE is shown in Fig 3. For comparability purposes, this shows the distribution of banded percentage forecast errors over the period from 1982:1 to 1990:4 for the 0 to 7 quarter forecast horizons and the period from

1980:2 to 1990:4 for the 8 quarter forecast horizon. Fig 3 shows the decreasing accuracy of TPI forecasts commensurate with increasing forecast horizons in terms of both bias and consistency. Only the zero quarter forecast horizon errors are anything like normally distributed and the other forecast horizons appear to be bi-modal.

Non-parametric analysis

Table 1 summarises the non-parametric analysis of the TPI forecast produced by BCIS between 1980:2 and 1990:4 for 0, 1, ..., 8 quarter forecast horizons in terms of mean error, mean absolute error, mean percentage error, RMSE, RMSE (percent) and Theil U^2. The standard deviations of the mean error, mean absolute error and mean percentage error are given to indicate the spread of these measures. All the measures of forecasting accuracy indicate a decrease in the accuracy of the forecast as the horizon of the forecast increases. The increase in standard deviation of ME, MEA and MPE as the horizon increases indicates an increase in uncertainty concerning future economic events. The forecast of TPI is positively biased, indicating a general over-estimation of TPI during this period as might be expected in these times of generally increasing building activity. The forecasts of TPI made between 1980:2 and 1981:1 were clearly high. A possible explanation for this is that this was a learning period for BCIS 'experts', as it coincided with the time when TPI forecasts were formally published for the first time.

Error decomposition

Decomposition of the mean square error of the TPI forecasts (after Theil, 1966) is shown in Table 2. These statistics are useful in identifying sources of TPI forecast error and thus offer the possibility of future correction or improvement in the TPI forecast.

Using Theil's first method of error decomposition, the values of the components show that the covariance proportion U^C accounts for a greater proportion of the MSE of the level of forecasts than the bias, U^M, and variance proportion, U^S. As the forecast horizon increases, U^C decreases while U^M increases, confirming the existence of a direct relationship between forecast horizon and over-estimation.

The second error decomposition method indicates that nearly all the MSE of the TPI forecasts is attributable to the regression proportion U^R. The F-statistics are significant at 5 percent confidence level ($p=0.000$ in all cases). This produces evidence that the forecasters made errors of a systematic nature and produced statistical grounds to support the hypothesis that $a = 0$ and $b = 1$. This being the case, the MSE of the forecast could be reduced using an optimal linear correction technique. The resulting estimated coefficients for each of the forecast horizons could be used as correction factors thus:

Where

A_t = Corrected forecast value

P = Predicted value

The regression proportion decreases with the forecast horizon which shows that the degree to which the MSE of TPI forecast could be reduced, decreases with increasing forecast horizon.

THE DL&E SYSTEM

Davis, Langdon and Everest (DL&E) is a private firm of chartered quantity surveyors and a profit making organisation, formerly known as Davis Belfield and Everest (DB&E) and Langdon and Every (L&E) until the end of 1987. DL&E has been involved in monitoring building prices since the early 1970s, though its first historical index and predictive index (forecast) of tender price was not published until 12 November 1975. This was published in *Architects' Journal* under the caption "technical study". In the 7th forecast feature (*Architects' Journal*, 26 October, 1977) of DB&E the caption was changed to "Building

Costs". In November 1982, the caption was changed again to "COST FORECAST". The *Architects' Journal* continued to publish the quarterly edition of the cost information from DL&E until 5 July 1989. DL&E resumed publication of tender price level information in the *Building* magazine with the caption "COST FORECAST" in October, 1989.

The DL&E tender price index reflects changes in the level of pricing in bills of quantities for accepted tenders in the outer London area. The forecast of TPI produced and published by DL&E is of the prediction interval form.

Forecasting system[2]

DL&E do not have a formal model for tender price forecasting. The forecast of TPI is based on "subjective assessment of in-house experts". The forecasting method being adopted by this organisation could best be described as qualitative or Delphic. Experts within the organisation confer to analyze the current economic climate and how this will affect the future prices of construction.

An important leading factor considered by the experts in forecasting tender price movements is the level of architects' appointments. The architects appointments advertisements are measured by determining the total area covered by advertisement for architects in *Architects' Journal*. The organisation has derived a lagged relationship between the architect appointment advertisement and market factor over time. Figs 4 and 5 show the annual and quarterly graphical illustrations, respectively, of correlation established by DL&E between the two variables. Normally, the 'Market Factor Index' provides a measure of how tender prices relate to building costs thus:

$$\text{Market factor index (MFI)} = \frac{\text{Tender Price Index (TPI)}}{\text{Building Cost Index (BCI)}}$$

[2] The information in this section was obtained directly from DL&E (Smith and Fordham, 1981).

However, the 'Market Factor Index' is pre-determined using the architects' appointment advertisement. Also the DL&E system is capable of forecasting the Building Cost Index with a high degree of accuracy. Having established these two indexes, a tentative tender price index forecast is calculated thus:

$$TPI = MFI \times BCI$$

Considering the tentative TPI prediction and other factors (financial, non-financial and prices) the 'experts' are able to arrive at the minimum and maximum tender price index forecasts for 0, 1, ..., 8 quarter forecast horizons.

However, this organisation considers that the building cost trend has little influence on the judgemental adjustments to the tender price index forecast. The most important factor, considered to have a major impact on DL&E forecasts of TPI, relates to market conditions and this predominantly includes interest rates, business confidence, general retail inflation and construction new orders.

DL&E monitors the accuracy of its published forecasts and is confident that its judgemental forecasting system is more accurate than those of a purely quantitative nature. The main difficulties in forecasting TPI, that they have identified, are in the accurate prediction of the timing of turning points in TPI and obtaining accurate forecasts of the general level of retail inflation beyond a two year time horizon.

Forecast accuracy

The forecast accuracy of the DL&E TPI was investigated, again using both graphical presentation and non-parametric tests of accuracy. The forecast period in this case covered the fifteen years between 1975:4 and 1990:4 for 0, 1, ..., 8 quarter forecast horizons. This provided 61 zero-quarters-ahead forecasts, 60 one-quarter-ahead forecasts, 59 two-quarter-ahead forecasts, ..., 53 eight-quarter-ahead forecasts.

Graphical presentation

Fig 6 presents the plots of actual and predicted values of the tender price index. The predictions show the minimum and maximum values. The plots presented in the figure relate to values (actual, minimum prediction and maximum prediction) between 1978:1 and 1990:4 to allow a standardized comparison of performances across forecast horizons. The plots of the predicted values cover the eight-quarter forecast horizon. The plots present a clear picture of the performance of the DL&E forecasts of the TPI.

Visual observation of these plots shows that the TPI forecasts generally track the actual levels closely up to the two quarter horizon. As DL&E make prediction interval forecasts, the actual values of TPI are expected to fall within the minimum and maximum predicted values in most cases. This was not so, however, for all two quarter and above forecast horizons, the actual values of TPI were either below the minimum predicted values or above the maximum predicted values. The disparity between actual and predicted values noticeably increases with increasing forecast horizons. The turning points in the predicted values occur about 2 to 4 quarters after the turning points in the actual values - an indication perhaps of the postmortem judgemental adjustment strategy in the DL&E forecast.

Non-parametric analysis

The predicted values of the TPI comprise the minimum and the maximum values only. In the absence of any other information, it is assumed that these values are intended to represent the limits of some symmetrical probability distribution of possible values. It can be shown that the best estimate of the expected value of such a distribution is the arithmetic mean of these maximum and minimum values. As the expected value of the forecast has an equal probability of being too high or too low, it is reasonable to assume, that this can be used to estimate the value of DL&E's absent point forecast of TPI.

Table 1 includes the results of the non-parametric analysis of the DL&E TPI estimated point forecasts between 1976:4 and 1990:4 for 0, 1, ..., 8 quarter forecast horizons. The non-parametric measures of forecasting accuracy employed are ME, MAE, and MPE with their respective standard deviations; RMSE, RMSE (percent) and Theil U^2. All the measures of forecasting accuracy point to a decrease in the accuracy of the estimated point forecasts as the horizon of the forecasts increases. The estimated point forecasts are generally positively biased, indicating a general over-estimation of the TPI.

COMPARISON BETWEEN THE BCIS AND THE DL&E SYSTEMS

The BCIS and DL&E are both involved in monitoring and forecasting TPIs. The tenders included in the compilation of the indexes published by these two organisations are drawn from both the public and the private sector. However, there are some differences associated with the monitoring and forecasting of the TPIs by these two organisations, thus:

1. the BCIS series indexes the price levels of new building work in the UK whilst the DL&E series indexes the price levels of new building work in the outer London area.

2. the BCIS base year is 1974 while the DL&E base year is 1976.

3. the BCIS provide point forecasts whilst DL&E provide prediction-interval forecasts.

4. the BCIS commenced publication of its TPI forecast in 1980 whilst DL&E commenced in 1976.

Despite these differences, there are few problems in comparing the accuracy of the TPI forecasts. Both TPIs index the same phenomenon, building price movements, and both are constructed in essentially the same manner. As would be expected, the indexes are highly correlated (r^2=0.970, n=68) and the impact of the small differences that do occur between the indexes can be lessened by the use of percentage rather than absolute error measures.

Comparative performance analyses were made, covering the entire period over which these two organisations published TPI forecasts (BCIS, 1980-1990; DL&E, 1976-1990), so that a period of learning could be equally included in the analysis. Table 1 gives the non-parametric summary analysis of the forecasting accuracy. Two measures of accuracy enable a direct comparison to be made between these two forecasts apart from graphical representation: RMSE(%) and Theil U^2. Although the DL&E's estimated point forecast at zero-quarter horizon performed better than the BCIS's, RMSE(%) and Theil U^2 show that the BCIS forecast of TPI was more accurate than DL&E estimated point forecast at all other forecast horizons over the time period examined.

Two other points also emerge from this analysis:

1. The forecast accuracy of these organisations has varied greatly over time. For example, whilst the BCIS were able to make relatively accurate forecasts between 1985:1 and 1987:4, this has not been the case in other periods. One possible explanation of this is that the period between 1985:1 and 1987:4 coincided with a steady growth in UK economic conditions, and that the reduced level of uncertainty associated with this period provided conducive conditions for more accurate economic forecasting. An unexpected decline in economic fortunes would therefore be

associated with a greater level of uncertainty and would lead to less accurate forecasts.

2. Fluctuations in forecast accuracy over this period could be attributable to the 'expert' forecasters. Different people have been involved in forecasting TPI values within these organisations (Martin, 1991; Smith and Fordham, 1991). These fluctuations in accuracy could therefore be attributable to lack of continuity and/or systematic differences in forecasting skills of the 'experts' involved.

A&S REDUCED-FORM EQUATION

In a recent paper, Akintoye & Skitmore (1993) described the development of models based on single structural and simultaneous equation techniques to explain the movements in macro building prices over the years 1974 to 1987. A reduced form simultaneous equation model was used to explain general movements, and a single structural model, based on economic theory, to explain structural movements in the TPI. Both models were found to fit the BCIS TPI well. Single structural models however are known to have an inferior predictive power to reduced-form equations (Kane, 1968:21-2; Neal and Shone, 1976) and therefore only the reduced-form equation is considered here.

This section examines the forecasting accuracy of the A&S reduced form model over different horizon lengths. It also determines if the model will display a tendency to accumulate errors as the forecasting horizon increases. As a result of data limitations, the three quarter time horizon is the maximum used.

A&S Reduced-form model

Akintoye and Skitmore's (1993) reduced-form model of construction price is a causal quantitative forecasting model involving the identification of variables that are related to construction price. The model is derived from the construction demand, supply and equilibrium equations for the period 1974 to 1987 as follows:

Demand equation $Q^d_t = -14.051 - 0.766P_{t-3} - 0.249U^E_{t-5} + 1.764M^p_{t-4} - 0.011R^r_{t-1} + 1.632Y^d$

Supply equation $Q^s_t = 1.049 + 0.970P_t + 0.628P^r_{t-4} - 0.695C^p_{t-2} - 0.019S^T_{t-3} + 0.239F^r_{t-8} - 0.0930^L_{t-1}$

Equilibrium equation $Q^s_t = 3.281 + 0.197Q^d_t + 0.158Q^d_{t-1} +$

$$0.106Q^{d}_{t-2} + 0.055Q^{d}_{t-3} + 0.02Q^{d}_{t-4} + 0.016Q^{d}_{t-5} + 0.058Q^{d}_{t-6}$$

where

Q^d Quarterly construction new orders

Q^s Quarterly construction output

PQuarterly Tender Price Index.

P^r Output per person employed in the construction industry.

C^p Quarterly Building Cost Index.

S^T The working days lost by workers both directly or indirectly involved in operation of construction industry due to industrial disputes.

F^r Number of registered private contractors.

O^L Dummy variable to reflect general increase in prices between 1978 and 1980 due to oil crisis (During this period of oil shock, the real price of crude oil went up by 110 percent): equal 1 between 1978:2 and 1980:2 and zero otherwise.

U^e Number claiming unemployment-related benefit at Unemployment Benefit Offices.

M^p Manufacturing output price/input cost ratio.

R^r Real rate of interest.

Y^d Quarterly gross national product.

P (tender price level) in these equations is therefore an endogenous variable. These equations are solved simultaneously for P by substituting the demand equation into the equilibrium equation and letting this equal the supply equation, giving

$$\begin{aligned}
P = {} & -6.424 - 0.647P^{r}_{t-4} + 0.716C^{p}_{t-2} + 0.0196S^{T}_{t-3} - 0.246F^{r}_{t-8} + 0.096O^{L}_{t-1} \\
& - (0.155P_{t-3} + 0.125P_{t-4} + 0.083P_{t-5} + 0.043P_{t-6} + 0.015P_{t-7} + 0.012P_{t-8} + 0.046P_{t-9}) \\
& - (0.050U^{E}_{t-4} + 0.041U^{E}_{t-5} + 0.027U^{E}_{t-6} + 0.014U^{E}_{t-7} + 0.005U^{E}_{t-8} + 0.004U^{E}_{t-9} + 0.015U^{E}_{t-10}) \\
& + (0.357M^{p}_{t-4} + 0.287M^{p}_{t-5} + 0.192M^{p}_{t-6} + 0.099M^{p}_{t-7} + 0.035M^{p}_{t-8} + 0.028M^{p}_{t-9} + 0.105M^{p}_{t-10}) \\
& - (0.002R^{r}_{t-1} + 0.002R^{r}_{t-2} + 0.001R^{r}_{t-3} + 0.0006R^{r}_{t-4} + 0.0002R^{r}_{t-5} + 0.0002R^{r}_{t-6} + 0.0006R^{r}_{t-7}) \\
& + (0.331Y^{d} + 0.266Y^{d}_{t-1} + 0.178Y^{d}_{t-2} + 0.091Y^{d}_{t-3} + 0.032Y^{d}_{t-4} + 0.026Y^{d}_{t-5} + 0.097Y^{d}_{t-6})
\end{aligned} \tag{20}$$

This reduced-form model readily produces forecasts of TPI at zero-quarter horizon. However, it can also be manipulated to produce the forecast of TPI up to three quarters horizon.

C^{p}, Y^{d} and R^{r} in the reduced-form model have the starting lagged distribution of 0, 0, and 1 respectively which suggests that these concurrent relationships have little forecasting value. Also, the starting point of distributed lags for the remaining variables is a three or more quarters lead, which does not pose forecasting problems. There are three options for dealing with the concurrent relationship variables in the model:

1. Forecasts of these concurrent independent variables for the relevant period could be used where available, provided the forecasts are very accurately predicted. An example in

this respect is C^p (Building Cost Index), which is known to have a high degree of accuracy (Fellows, 1988).

2. These variables could be simulated provided they have either a fairly steady growth, decay or zero trend. A problem does arise however when the trends in exploratory variables fluctuate markedly. Such trends in economic variables may be associated with and/or lead to slump (recession) or boom (recovery) in the economy. This is always a problem in economic forecasts and may result in large errors (McNees and Rees, 1983).

3. The current values of these variables could be lagged 3, 2, or 1 quarter ahead of TPI depending on the forecast span (horizon) intended. Fig 7 provides an illustration of how the current value of Y^d for example, could be used in predicting TPI up to a three quarters horizon. As the latest values of the variable become available, the forecast is revised to fit the new information (after McNees, 1986).

Here we adopt options 1 and 3 for forecasting purposes. It should be noted that the in-sample and post-sample forecasts analysed are purely mechanically-generated reduced-form model based forecasts. No 'expert' opinion or delphic-like adjustment has been made.

Non-parametric analysis

Ex post simulation or "historical" simulation forecast accuracy

The simultaneous equation estimation was based on quarterly data from 1974:1 to 1987:4. This period is regarded, therefore, as the in-sample period. The in-sample non-parametric forecast accuracy of the A&S model of construction price is shown in Table 1. The RMSE is less than 10 in all cases. The percentage error of less than 5 percent across the forecast horizon indicates that the model as a whole does not display any substantial tendency to accumulate errors as the forecasting horizon lengthens. Though the MPE and ME statistics show negative signs, their standard deviations (spread) indicate an almost equal tendency of the model towards under-prediction and over-prediction.

Ex post forecast accuracy

1988:1 to 1990:4 is the ex-post or out-sample period. Co-incidentally, this period is of special interest because it has witnessed a significant downturn in the tender price level, coupled with a severe economic recession. The non-parametric forecast accuracy of the A&S model of construction price was compared with the accuracy of the BCIS forecasts and DL&E

estimated point forecasts **over the same period**. Table 3 contains error statistics for the forecasts. The table indicates, interestingly, that the post-sample error statistics for the A&S model are not significantly larger than its in-sample error statistics. The table also shows that the A&S model has a better predictive behaviour than the BCIS forecasts and the DL&E estimated point forecasts. RMSE (percent) of the A&S model forecasts is less than 6 percent in all cases over the three-quarter forecast horizon. The A&S model, however, generally underestimated the TPI values compared to a general overestimation of the BCIS forecasts and the DL&E estimated point forecasts.

Graphical presentation

Fig 8, which shows the graphical plots of actual values of TPI and the predicted values from 1976 through 1990, presents a clear picture of the performance of the A&S model in tracking the historical record.

Ex post simulation - within sample

The period 1976:2 to 1987:4 represents the in-sample period. As expected, the model simulates the historical record quite well particularly over the zero-quarter and one-quarter forecast horizon. The figure shows the results for 0, 1, 2, 3 quarter forecast horizons indicating that the A&S model can predict the turning point in the TPI movements not later than a quarter thereafter.

Ex post forecast - post sample

1988:1 to 1990:4 is the out-sample or *ex post* forecast period. The magnitude and direction of the forecasting errors are illustrated by the plot over the three-quarter forecast horizon. The visual disparity between actual values and predicted values during the *ex post* forecast period is not as pronounced as in the BCIS forecasts and the DL&E estimated point forecasts.

The over-prediction of the model from 1989:4 is probably due to the continuous severity of the recession. The model does seem to anticipate the recession through its impact on GNP, the unemployment level and interest rate. However, there are other factors associated with the recession that are not anticipated. Clearly, the suddenness of the current recession was not anticipated by any of the systems.

COMPARISON BETWEEN BCIS, DL&E AND A&S SYSTEMS

Table 1 compares the forecast accuracy of these systems has varied over different forecast horizons and forecast periods. The periods 1979:2 to 1981:2, 1984:3 to 1986:1 and 1989:1 to date are associated with recessions in the UK. The largest forecast errors occurred during these recessionary periods and increased with the length of time span (forecast horizon). This is not unusual in economic forecasts (McNees and Ries, 1983) particularly in a changing economy. Longer time spans involve larger changes for most economic variables and this is reflected in the larger errors as the time span increases.

A valid comparison of different forecasts requires that the forecasts are examined over the same forecast horizon and period. The A&S system is capable of forecasting TPI up to a three quarter horizon in its present form and hence may be compared with the BCIS and DL&E systems over the same forecast horizon. The BCIS and DL&E systems have different forecast periods due to different commencements of publication. To ensure that the learning period of these two systems are taken into consideration, all the periods of the forecast of these systems are compared with the A&S system in-sample forecasts (Table 1). The reliability of the A&S system is examined by comparing the A&S out-sample forecasts with the BCIS and DL&E

forecasts over the same period.

Figs 9 and 10 compares the BCIS and DL&E forecast accuracy with the A&S in-sample and out-sample forecast accuracy respectively. These comparisons show that the A&S system generally produces better in-sample and out-sample forecasts than BCIS and DL&E with the exception of in-sample forecasts for the zero quarter forecast horizon.

SUMMARY AND CONCLUSION

This paper analyses the accuracy of TPI forecasts produced and published by Building Cost Information Service between 1980 and 1990 and Davis Langdon and Everest forecasts between 1976 and 1990. The disparities between the actual values of TPI and the predicted values published by these organisations increased with increasing forecast horizon.

Comparisons were made between the actual forecasts published by the Building Cost Information Service and the estimated point forecasts of Davis, Langdon & Everest and simulated out-sample forecasts made by the Akintoye and Skitmore system over the years 1988 to 1990. It is shown that the Akintoye and Skitmore system gives the most accurate forecasts for a zero to three quarters forecast horizon for which it is capable of producing forecasts in its present form.

Two points are worthy of note concerning this analysis. Firstly, only the static form of the Akintoye and Skitmore system is examined here. The coefficients of the model were estimated once only, at the end of 1987. Clearly we would expect these estimates to deteriorate over time so that using the 1987 model in 1989 to make forecasts for 1990 is not likely to be as good as using a 1989 calibrated model to make forecasts for 1990. In other words, we would expect a dynamic version of this system, taking into account all the data available at the time of forecast, to produce more accurate forecasts than the static version examined here.

Secondly, the forecasts produced by the A&S model are purely mechanically-generated. It is possible that the accuracy of forecasts based on the A&S model could be improved further if used as a forecasting tool by experts. In this respect, experts would be expected to be capable of making "objective" judgemental adjustments of the mechanically-generated model-based forecasts. Such adjustments are a common feature of forecasting systems of these kind, including the BCIS and DL&E systems examined here. Whether human interference will really be beneficial is clearly an empirical matter yet to be studied. The major issues have however been suggested in this paper and these concern the abilities and experience of the 'expert' both in price forecasting generally and in coping with rapidly changing economic circumstances.

Finally, it should be emphasised that the time period studied was of special interest, in that it contained a significant downturn in tender price levels together with a severe economic recession. Whilst the analysis of this period has shed some light on forecasting behaviour under such conditions, it is not easy to generalise these findings to other economic circumstances. Indeed, it is not inconceivable that the very process of publishing these results may influence the future behaviour of forecasters in an unpredictable way.

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REFERENCES

Akintoye, A.S., Skitmore, R.M., 1993, Macro models of UK construction prices, *Civil Engineering Systems* (in print).

BCIS, 1974-90, *Statistics and economic indicators*, Sub-section AG.

BCIS, 1987, BCIS - A policy statement, *BCIS NEWS*, March, No.13

Bowerman, B.L., O'Connel, R.T., 1987, *Time series forecasting,* Boston, Duxbury Press.

Dhrymes, P.J., Howrey, E.P., Hymans, S.H., Kmenta, J., Leamer, E.E., Quandt, R.E., Ramsey, H.T., Shapiro, H.T., Zarnowitz, V., 1972, Criteria for evaluation of econometric models, *Annals of Economics and Social Measurement*, **1**(3), 291-324.

Evans, M.K., Haitovsky, Y., Treyz, G.I., 1972, An analysis of the forecasting properties of U.S economic models, in *Econometric Models of Cyclical Behaviour*, B.G. Hickman, ed., National Bureau of Economic Research, Studies in Income and Wealth, No.36, New York, NBER, 949-1139.

Fellows, R.F., 1988, Escalation management, PhD *thesis*, Department of Construction Management, University of Reading.

Haitovsky, Y., Treyz, G.I., 1972, Forecasts with quarterly macroeconomic models, equation adjustments and benchmark predictions: The U.S. experience, *Review of Economics and Statistics*, **54**, Aug, 317-25.

Holden, K., Peel, D.A., 1988, A comparison of some inflation, growth and unemployment forecast, *Journal of Economic Studies*, **15**(5), 45-52.

Kahneman, D., Tversky, A., 1982, Intuitive prediction: Biases and corrective procedures, in *Judgement Under Uncertainty: Heuristics and Biases*, Kahneman, Slovic and Tversky, eds., Cambridge University Press, New York, 414-21.

Kane, E.J., 1968, *Economic statistics and econometrics: an introduction to quantitative economics*, Harper and Row, London.

Lucas, R.E. Jr., 1976, Economic policy evaluation, a critique, in *The Phillips Curve and Labour Markets*, K. Brunner and A.H. Meltzler, eds., Carnegie-Rochester Conference on Public Policy, 1.

McCaffer, R., McCaffrey, M.J., Thorpe, A., 1983, The disparity between construction cost and tender price movements, *Construction papers*, **2**(2), 17-27.

McNees, S.K., 1985, Which forecast should you use?, *New England Economic Review*, Jul/Aug, 36-42.

McNees, S.K., 1986, Estimating GNP: the trade-off between timeliness and accuracy, *New England Economic Review*, Jan/Feb, 3-10.

McNees, S.K., 1989, Why do forecast differs, *New England Economic Review*, Jan/Feb, 42-54.

McNees, S.K., 1990, Man Vs Models? The role of judgement in forecasting, *New England Economic Review*, Jul/Aug, 41-52.

McNees, S.K., Ries, J., 1983, The track record of macroeconomic forecasts, *New England Economic Review*, Nov/Dec, 5-18.

Makridakis, S., 1984, Forecasting: state of the art, in *The forecasting accuracy of major time series methods*, Makridakis, S *et al*, John Wiley & Sons, New York, 1-17.

Makridakis, S., Hibon, M., 1984, Accuracy of forecasting: an empirical investigation, in *The Forecasting Accuracy of Major Time Series Methods*, Makridakis, S, *et al*, John Wiley & Sons, New York, 35-59.

Martin, J.L.N., 1991, Personal communication.

Neal, F., Shone, R., 1976, *Economic model building*, McMillan, London.

O'Donovan, T.M., 1983, *Short term forecasting: an introduction to the Box-Jenkins approach*, John Wiley & Sons, New York, 5-7.

Pindyck, R.S., Rubinfeld, D.L., 1976, *Econometric models and economic forecasts*, McGraw-Hill, New York.

Sim, C.A., 1980, Macroeconomics and Reality, *Econometrica*, **48**, Jan, 1-48.

Skitmore, M., Stradling, S., Tuohy, A., Mkwenzalamba, H., 1990, *Accuracy of construction price forecasts*, The University of Salford, Salford, UK.

Smith, R., Fordham, P., 1991, Personal communication.

Theil, 1966, *Applied economic forecasting*, North Holland Publishing Company, Amsterdam.

Trehan, B., 1989, Forecasting growth in current quarter real GNP, *Economic Review, Federal Reserve Bank of San Francisco*, Winter, pp. 39-51.

Zarnowitz, V., 1979, An analysis of annual and multiperiod quarterly forecast of aggregate income, output and price level, *Journal of Business*, **52**(1), Jan, 24-38.

FIGURES AND TABLES

List of Captions

Figures

Fig 1: Types of economic forecast
Source: Pindyck & Rubinfeld (1976:313).

Fig 2: Actual and predicted tender price index
Source: Building Cost Information Service 24-month index forecast

Fig 3: Frequency distribution of forecast mean percentage error

Fig 4: Relationship between Architects' appointments advertised in Architects Journal and DL&E Market Factor (based on first quarter each year)
Source: Davis, Langdon and Everest.

Fig 5: Relationship between Architects' appointments advertised in Architects Journal and DL&E Market Factor (on quarterly basis)
Source: Davis, Langdon and Everest.

Fig 6: Actual and Predicted Tender Price Index
Source: Davis, Langdon and Everest.

Fig 7: Lag relationship between P and Y^d

Fig 8: Actual and predicted Tender Price Index, A&S Reduced-form model of construction price.

Fig 8 (contd): Actual and predicted Tender Price Index, A&S Reduced-form model of construction price.

Tables

Table 1: Comparative analysis of forecasting accuracy of the A&S Model forecast, BCIS forecast and DL&E estimated point forecast (1975:4 - 1990:4)

Table 2: Decomposition of Mean Squared Error (MSE) of TPI forecast

Table 3: Comparative analysis of forecasting accuracy of the A&S Model forecast, BCIS forecast and DL&E estimated point forecast (1988:1 - 1990:4)

Table 1: Comparative analysis of forecasting accuracy of the A&S Model forecast, BCIS forecast and DL&E estimated point forecast (1975:4 - 1990:4)

Forecast horizon

		0			1			2			3			4			5			6			7			8		
		DL&E	BCIS	A&S	DL&E	BCIS	A&S	DL&E	BCIS	A&S	DL&E	BCIS	A&S	DL&E	BCIS	A&S	DL&E	BCIS	A&S	DL&E	BCIS	A&S	DL&E	BCIS	A&S	DL&E	BCIS	A&S
	4	-1.0																										
1976	1	0.0			9.0																							
	2	-1.0			0.0			10.0																				
	3	1.0		7.0	-4.0		8.4	0.0		7.2	7.0		4.0															
	4	1.0		6.4	1.0		10.5	-1.0		10.0	-1.0		8.6	7.0														
1977	1	-1.0		12.2	0.0		15.2	-1.0		16.2	-3.0		11.8	-2.0			12.0											
	2	1.0		8.1	2.0		12.3	3.0		10.7	1.0		11.2	-2.0			4.0			13.0								
	3	-1.0		5.9	1.0		14.7	2.0		13.4	2.0		12.9	0.0			-5.0			-2.0			11.0					
	4	1.0		7.8	0.0		15.9	2.0		16.1	-2.0		18.0	3.0			-3.0			-3.0			-3.0			11.0		
1978	1	-1.0		8.7	-1.0		13.4	-1.0		12.2	1.0		10.3	3.0			2.0			-2.0			-6.0			-6.0		
	2	-1.0		1.7	-1.0		3.7	-1.0		8.5	-3.0		7.6	0.0			3.0			1.0			-2.0			-9.0		
	3	-2.0		-3.0	-3.0		-1.2	-3.0		0.8	-5.0		5.0	-8.0			-1.0			0.0			-2.0			-14.0		
	4	2.0		-1.2	-12.0		-6.3	-13.0		-4.4	-14.0		-2.2	-16.0			-18.0			-12.0			-10.0			-11.0		
1979	1	1.0		1.4	1.0		-0.2	-13.0		-5.6	-14.0		-5.9	-15.0			-17.0			-20.0			-12.0			-10.0		
	2	2.0		-0.8	-1.0		-3.5	-1.0		-5.0	-14.0		-11.5	-15.0			-16.0			-18.0			-23.0			-13.0		
	3	-2.0		-11.7	1.0		-8.3	-3.0		-11.1	-3.0		-13.0	-18.0			-19.0			-18.0			-18.0			-27.0		
	4	-1.0		-1.6	-5.0		-1.3	-2.0		2.5	-8.0		0.8	-8.0			-22.0			-22.0			-22.0			-22.0		
1980	1	-8.0		2.0	-10.0		7.7	-14.0		7.9	-11.0		10.8	-17.0			-17.0			-32.0			-32.0			-34.0		
	2	-2.0	1.0	-1.3	-25.0		0.0	-27.0		5.9	-29.0		5.5	-35.0			-35.0			-35.0			-50.0			-50.0		
	3	13.0	2.0	-5.9	12.0	16.0	-3.4	1.0		-2.1	0.0		3.8	-8.0			-29.0			-17.0			-17.0			-33.0		
	4	5.0	8.0	0.2	17.0	15.0	-23.5	22.0	31.0	-21.4	12.0		-16.1	15.0			26.0			25.0			18.0			17.0		
1981	1	-7.0	-18.0	-9.3	-4.0	14.0	-8.7	14.0	21.0	-8.9	7.0	47.0	-13.0	-1.0			1.0			-8.0			-8.0			-21.0		
	2	4.0	-4.0	9.2	2.0	-17.0	5.1	4.0	17.0	5.5	24.0	25.0	6.4	21.0	53.0		8.0			11.0			0.0			-2.0		
	3	3.0	7.0	5.4	15.0	3.0	9.5	7.0	-7.0	5.4	20.0	28.0	6.5	45.0	42.0		42.0	69.0		26.0			33.0			3.0		

	4	-2.0	8.0	13.3	5.0	18.0	14.0	13.0	12.0	18.4	15.0	0.0	20.4	18.0	33.0	43.0	51.0	40.0	79.0	24.0		28.0	
1982	1	11.0	-13.0	0.1	9.0	1.0	-1.6	13.0	11.0	-1.0	20.0	5.0	2.2	22.0	-8.0	24.0	25.0	50.0	49.0	46.0	82.0	28.0	
	2	4.0	1.0	0.8	16.0	-9.0	6.6	12.0	6.0	4.9	20.0	16.0	5.8	25.0	16.0	27.0	-3.0	31.0	31.0	56.0	57.0	49.0	89.0
	3	5.0	1.0	1.6	4.0	15.0	0.9	21.0	2.0	6.7	13.0	19.0	4.1	27.0	32.0	30.0	35.0	24.0	22.0	39.0	50.0	47.0	75.0
	4	3.0	-1.0	-2.1	4.0	-1.0	-1.7	8.0	13.0	-2.3	24.0	2.0	5.0	25.0	20.0	32.0	40.0	32.0	37.0	37.0	27.0	39.0	52.0
1983	1	2.0	8.0	-2.5	3.0	9.0	-3.7	7.0	1.0	-3.3	11.0	17.0	-5.2	29.0	11.0	31.0	28.0	40.0	47.0	36.0	45.0	36.0	35.0
	2	0.0	6.0	-7.9	3.0	7.0	-4.8	5.0	3.0	-6.0	9.0	4.0	-5.8	13.0	23.0	32.0	12.0	38.0	34.0	44.0	52.0	40.0	48.0
	3	11.0	4.0	-7.5	17.0	14.0	-8.5	17.0	18.0	-5.4	17.0	11.0	-7.1	24.0	15.0	28.0	36.0	52.0	26.0	52.0	52.0	61.0	66.0
	4	9.0	0.0	0.4	11.0	1.0	-2.0	15.0	9.0	-2.9	19.0	18.0	-0.3	22.0	9.0	27.0	15.0	32.0	37.0	57.0	25.0	50.0	53.0
1984	1	-1.0	-2.0	-3.4	6.0	10.0	-4.7	11.0	4.0	-7.1	14.0	11.0	-10.6	19.0	17.0	22.0	11.0	28.0	18.0	34.0	41.0	52.0	30.0
	2	2.0	-2.0	8.7	2.0	5.0	5.9	10.0	9.0	4.8	14.0	6.0	2.1	18.0	18.0	23.0	20.0	25.0	18.0	28.0	26.0	33.0	51.0
	3	3.0	6.0	-5.5	3.0	3.0	-5.0	2.0	9.0	-7.7	6.0	14.0	-9.6	19.0	14.0	19.0	25.0	24.0	25.0	33.0	27.0	38.0	38.0
	4	6.0	-4.0	-4.0	5.0	-3.0	-2.8	5.0	-6.0	-2.3	4.0	0.0	-4.4	18.0	4.0	23.0	6.0	23.0	17.0	29.0	17.0	22.0	24.0
1985	1	3.0	2.0	7.2	10.0	4.0	5.5	8.0	5.0	6.7	8.0	1.0	4.3	8.0	4.0	23.0	10.0	28.0	13.0	29.0	21.0	29.0	26.0
	2	1.0	-16.0	-2.5	0.0	-9.0	-2.0	8.0	-6.0	-3.7	8.0	-6.0	0.7	8.0	-9.0	8.0	-2.0	24.0	4.0	29.0	3.0	25.0	16.0
	3	8.0	-3.0	8.0	10.0	-3.0	5.8	9.0	2.0	6.3	19.0	6.0	3.1	18.0	7.0	18.0	3.0	18.0	10.0	29.0	13.0	29.0	18.0
	4	3.0	-5.0	-10.0	8.0	-10.0	-11.9	12.0	-10.0	-14.0	10.0	-3.0	-9.0	23.0	-1.0	22.0	0.0	22.0	-4.0	22.0	2.0	28.0	10.0
1986	1	1.0	3.0	-6.1	3.0	1.0	-7.3	11.0	1.0	-9.2	13.0	2.0	-13.5	11.0	7.0	24.0	13.0	24.0	10.0	24.0	6.0	21.0	17.0
	2	-2.0	-5.0	-14.1	-2.0	-5.0	-13.4	0.0	1.0	-14.6	9.0	1.0	-16.2	10.0	1.0	9.0	10.0	24.0	12.0	24.0	8.0	19.0	8.0

	3	-1.0	-10.0	-14.9	-3.0	-2.0	-18.0	-2.0	-1.0	-17.2	-2.0	1.0	-18.2	9.0	2.0	12.0	2.0	10.0	9.0	26.0	14.0	26.0	14.0
	4	5.0	-3.0	-11.5	1.0	-3.0	-8.7	0.0	2.0	-11.8	0.0	4.0	-10.3	4.0	8.0	11.0	10.0	13.0	9.0	13.0	16.0	29.0	19.0
1987	1	-5.0	3.0	-1.1	0.0	-10.0	-7.3	-6.0	-10.0	-4.2	-7.0	-5.0	-11.3	-7.0	-1.0	-1.0	0.0	6.0	2.0	8.0	2.0	7.0	7.0
	2	-2.0	8.0	-6.4	-10.0	12.0	-9.4	-3.0	-3.0	-15.2	-8.0	-3.0	-11.6	-12.0	0.0	-11.0	6.0	-6.0	8.0	0.0	11.0	2.0	10.0
	3	-8.0	10.0	9.8	-9.0	9.0	5.3	-17.0	14.0	2.1	-10.0	-1.0	-3.1	-15.0	-1.0	-18.0	7.0	-18.0	13.0	-17.0	15.0	-5.0	17.0
	4	-4.0	-9.0	-8.7	-15.0	-8.0	-11.1	-20.0	-9.0	-15.6	-28.0	-2.0	-17.7	-22.0	-17.0	-27.0	-16.0	-29.0	-9.0	-30.0	-7.0	-26.0	-3.0
1988	1	1.0	-13.0	-12.6	-5.0	-11.0	-18.4	-18.0	-11.0	-21.1	-21.0	-12.0	-29.2	-35.0	-8.0	-28.0	-21.0	-24.0	-21.0	-38.0	-17.0	-37.0	-12.0
	2	0.0	0.0	6.4	2.0	-13.0	2.2	-6.0	-12.0	-4.0	-21.0	-11.0	-5.1	-22.0	-12.0	-42.0	-8.0	-36.0	-21.0	-41.0	-21.0	-36.0	-18.0
	3	-10.0	2.0	-5.4	-9.0	-2.0	-9.6	-8.0	-16.0	-13.7	-18.0	-14.0	-21.8	-34.0	-14.0	-35.0	-16.0	-53.0	-14.0	-45.0	-27.0	-51.0	-27.0
	4	5.0	19.0	-7.2	-21.0	8.0	-12.1	-1.0	2.0	-16.2	0.0	-15.0	-17.7	-15.0	-14.0	-35.0	-14.0	-40.0	-16.0	-57.0	-13.0	-50.0	-28.0
1989	1	3.0	-2.0	-8.3	1.0	15.0	-13.0	-1.0	5.0	-17.6	-1.0	-3.0	-25.2	0.0	-21.0	-17.0	-23.0	-40.0	-23.0	-43.0	-25.0	-68.0	-22.0
	2	12.0	10.0	-6.3	11.0	5.0	-4.4	11.0	24.0	-8.9	9.0	14.0	-9.8	98.0	5.0	11.0	-15.0	-8.0	-15.0	-33.0	-15.0	-33.0	-17.0
	3	6.0	8.0	-8.7	23.0	17.0	-11.3	30.0	8.0	-9.1	33.0	23.0	-14.2	21.0	16.0	21.0	5.0	23.0	-14.0	2.0	-10.0	-19.0	-10.0
	4	1.0	24.0	13.0	7.0	27.0	14.7	28.0	34.0	12.0	28.0	29.0	17.3	38.0	40.0	28.0	36.0	28.0	24.0	30.0	4.0	6.0	5.0
1990	1	25.0	2.0	9.5	29.0	24.0	9.2	38.0	34.0	10.9	62.0	36.0	3.2	62.0	29.0	70.0	43.0	58.0	37.0	58.0	25.0	61.0	6.0
	2	15.0	2.0	3.8	22.0	7.0	9.7	39.0	33.0	9.4	50.0	43.0	13.8	76.0	48.0	73.0	38.0	81.0	53.0	68.0	44.0	68.0	33.0
	3	0.0	17.0	10.0	5.0	20.0	10.3	18.0	30.0	16.2	47.0	61.0	17.5	79.0	68.0	88.0	73.0	95.0	56.0	105.0	69.0	82.0	62.0
	4	10.0	2.0		22.0	29.0		28.0	31.0		40.0	41.0		81.0	72.0	88.0	87.0	119.0	87.0	121.0	70.0	136.0	81.0
ME		2.07	1.26	-0.37	2.72	4.83	-0.43	4.78	7.34	-0.65	6.40	10.25	-0.97	9.28	13.03	10.16	15.74	11.73	17.57	12.15	19.14	10.13	22.03

SD	5.76	8.45	7.12	9.93	11.15	9.01	13.11	13.65	9.60	18.03	17.40	9.79	25.17	22.07	29.07	25.70	33.43	26.40	36.77	27.81	38.58	30.36
MAE	4.13	6.37	5.84	7.38	9.88	7.40	10.27	11.78	8.14	14.16	14.00	8.39	19.84	18.46	24.30	21.95	27.84	24.97	31.00	26.64	32.21	29.86
SD	4.51	5.69	4.09	7.18	7.08	5.15	9.45	10.08	5.13	12.87	14.56	5.13	18.06	17.78	18.91	20.65	21.91	19.54	23.20	20.74	23.52	22.70
RMSE	6.12	8.55	7.13	10.30	12.15	9.02	13.96	15.50	9.62	19.13	20.20	9.84	26.83	25.63	30.80	30.13	35.43	31.71	38.72	33.76	39.88	37.51
RMSE (%)	2.93	3.27	3.48	4.86	4.66	4.39	6.47	5.74	4.69	8.72	7.60	4.79	11.97	9.87	13.57	11.94	15.36	12.91	16.61	14.10	17.10	16.01
U^2	.0008	.0011	.0012	.0022	.0022	.0018	.0039	.0036	.0021	.0073	.0061	.0022	.0142	.0097	.0184	.0133	.0240	.0146	.0283	.0163	.0296	.0200
MPE	0.84	0.37	-0.32	1.16	1.83	-0.56	1.98	2.85	-0.48	2.44	4.07	-0.28	3.67	5.34	4.24	6.61	5.02	7.56	5.39	8.37	4.50	9.74
SD	2.37	3.25	3.79	4.38	4.28	3.36	5.60	4.99	5.35	7.31	6.43	5.30	10.05	8.31	11.91	9.94	13.55	10.46	15.08	11.34	15.88	12.70
MAPE	1.86	2.50	3.02	3.37	3.86	4.00	4.66	4.44	4.32	6.27	5.38	4.30	8.69	7.25	10.76	8.70	12.18	10.00	13.56	10.82	14.16	12.32
SD	1.68	2.13	2.30	3.02	2.65	5.19	3.68	3.58	3.20	4.49	5.48	3.00	6.23	6.86	6.64	8.36	7.78	8.35	8.52	9.21	8.48	10.53

Note: The A&S values are for in-sample errors for 1976:3 to 1987:4 period and out-sample errors for 1988:1 to 1990:3 period. The summary statistics for A&S are for the in-sample period only. The summary statistics for the out-sample period are given in Table 3.

Table 3: Comparative analysis of forecasting accuracy of the A&S Model forecast, BCIS forecast and DL&E estimated point forecast (1988:1 - 1990:4)

	Forecast horizon																										
	0			1			2			3			4			5			6			7			8		
	DL&E	BCIS	A&S	DL&E	BCIS	A&S	DL&E	BCIS	A&S	DL&E	BCIS	A&S	DL&E	BCIS	A&S	DL&E	BCIS	A&S	DL&E	BCIS	A&S	DL&E	BCIS	A&S	DL&E	BCIS	A&S
ME	5.57	7.18	-0.54	7.25	12.00	-2.10	13.17	15.27	-3.83	17.33	18.09	-6.48	21.67	19.27		18.50	18.27		16.92	13.55		10.58	8.73		4.25	5.45	
SD	8.57	7.57	8.72	14.30	11.49	0.43	18.76	18.21	2.11	28.44	25.48	4.21	42.67	32.75		48.51	37.13		56.96	37.81		60.93	36.18		63.16	36.40	
MAE	7.33	5.55	8.30	13.08	14.73	10.44	18.83	20.36	12.63	27.50	25.91	15.89	39.33	30.36		44.67	32.09		50.42	32.82		53.42	30.00		54.58	28.55	
SD	7.19	7.20	2.73	9.27	7.69	9.65	13.06	12.25	11.79	18.79	17.47	14.56	27.25	22.84		26.47	26.13		31.45	23.16		31.16	22.03		32.05	25.23	
RMSE	10.27	10.43	8.74	16.03	16.61	11.26	22.92	23.76	13.46	33.31	31.25	17.60	47.85	38.00		51.92	41.38		59.42	40.17		61.84	37.22		63.30	36.80	
RMSE (%)	3.21	3.32	2.78	5.01	5.29	3.56	7.16	7.57	4.28	10.41	9.96	5.59	14.95	12.11		16.23	13.18		18.57	12.80		19.33	11.86		19.78	11.72	
U^2	.0010	.0011	.0008	.0025	.0028	.0013	.0051	.0066	.0018	.0108	.0099	.0031	.0223	.0146		.0262	.0173		.0343	.0016		.0372	.0140		.0390	.0137	
MPE	1.77	2.27	-0.18	2.27	3.75	-0.69	4.04	4.77	-1.27	5.36	5.68	-2.13	6.83	6.13		5.90	5.88		5.59	4.39		3.65	2.87		1.81	1.86	
SD	2.69	2.40	2.80	4.49	3.74	3.56	5.97	5.83	4.15	9.13	8.22	5.28	13.90	10.62		15.75	12.04		18.52	12.24		19.78	11.72		20.56	11.86	
MAPE	2.29	2.38	2.65	4.10	4.67	3.33	5.93	6.46	4.04	8.73	8.24	5.09	12.60	9.70		14.28	10.26		16.11	10.50		17.08	9.63		17.45	9.21	
SD	2.26	2.29	0.91	2.92	2.50	1.43	4.10	3.88	1.59	5.99	5.65	2.54	9.01	7.50		8.88	8.61		10.71	7.67		10.63	7.26		11.01	7.70	