Chapter Eight

The Predictive Accuracy of the Model

8.1 INTRODUCTION

The predictive accuracy of the empirical model is examined in this chapter. In the next section the predictive accuracy of my forecasting model [14] is compared to the predictive accuracy of other models. It is argued in this section that the forecasting model appears, from previous results, to be at least as accurate as other models. In section 8.3 the predictive accuracy of the empirical model is compared to the predictive accuracy of the forecasting model. The results presented in this section indicate that the empirical model is more accurate than the forecasting model. This indirect comparison of the empirical model with other models thus indicates that the empirical model is more accurate. This conclusion is, as mentioned in section 1.1, clearly tentative, and further tests and comparisons are needed before one can hold this conclusion with much confidence.

The following comparisons are of ex post predictive accuracy, not ex ante. An ex post forecast is a forecast that has been generated from a model in a mechanical way (no subjective constant-term adjustments) using the actual values of the exogenous variables. An ex ante forecast is an actual forecast released by a model builder for a future period. It is based on guessed values of the exogenous variables and may also have been generated from a model to which subjective constant-term adjustments were applied.

Comparisons of the ex ante forecasting records of model builders, which have been made in two recent studies by McNees [34], [35], are not valid comparisons of the models. Because of the extensive use of subjective constant-term adjustments by most model builders in actual forecasting situations, the accuracy of the ex ante forecasts may not be at all a good indicator of the accuracy of the models. Even if subjective constant-term adjustments are not applied to a model, as in the case of my work with the forecasting model, the accuracy of the ex ante forecasts from the model is still affected by the use of guessed rather than actual values of the exogenous variables. In evaluating the accuracy of a model qua model it is clear that actual rather than guessed values of the exogenous variables should be used. This is not to say, however, that the kinds of comparisons that McNees has made are not of interest. They are clearly of interest to people who want to know who are currently the most accurate forecasters.

8.2 A COMPARISON OF THE FORECASTING MODEL WITH OTHER MODELS

The results in Fromm and Klein [26] indicate that my forecasting model is at least as accurate, if not more so, than other models. Fromm and Klein's results cover nine quarterly econometric models, four variables (GNP in current dollars, GNP in constant dollars, the GNP deflator, and the unemployment rate), two error measures (root mean square errors of levels and first differences), and both within sample and outside sample forecasts (all ex post forecasts). The within sample forecast periods are roughly the same for all of the models, although the outside sample forecast periods are not.

One can get an indication of how the forecasting model performed relative to the other eight models from the results in Table 8–1. Table 8–1 presents the rank of the model against the other models for each possible category. For the within sample results, which are based on roughly the same period, the model is generally at or near the top. The results are not particularly good for the three- through five-quarter-ahead forecasts of the unemployment rate, but are quite good for the three- through five-quarter-ahead forecasts of the other three variables. For the outside sample results, the model is always best for the two GNP variables. The model is not only best for these variables, but is best by a substantial amount, as can be seen from examining Tables 1 and 2 in [26]. For the GNP deflator, the outside sample results deteriorate after three quarters ahead, and for the unemployment rate the outside sample results are not very good.

The outside sample results, while providing a more stringent test of the models, must be interpreted with some caution here because of the different forecast periods used. It is also the case that the forecasting model was reestimated up to the first quarter being forecast for each set of outside sample forecasts, so that, for example, each five-quarter-ahead forecast was never more than five quarters away from the end of the estimation period. This was not true for the other models, although the outside sample forecast period for each model did always begin with the quarter immediately following the end of its (one) estimation period.

Although the overall results in [26] are not completely unambig-

Table 8–1. The Ranking of the Forecasting Model Against Eight Other Quarterly Models (Results Are from Fromm and Klein [26], Tables 1, 2, 3, and 4)

RMSE = Root Mean Square Error of Level Predictions
*RMSE*Δ = Root Mean Square Error of First Difference Predictions

Variable	*One Quarter Ahead*		*Two Quarters Ahead*		*Three Quarters Ahead*		*Four Quarters Ahead*		*Five Quarters Ahead*	
	RMSE	*RMSE*Δ	*RMSE*	*RMSE*Δ	*RMSE*	*RMSE*Δ	*RMSE*	*RMSE*Δ	*RMSE*	*RMSE*Δ
Within Sample										
Current Dollar GNP	4 (9)	4 (8)	2 (9)	1 (8)	1 (9)	3 (8)	1 (9)	3 (8)	1 (8)	3 (7)
Constant Dollar GNP	3 (9)	3 (8)	6 (9)	1 (8)	3^{T}(9)	3 (8)	2 (9)	3 (8)	1 (8)	2 (7)
GNP Deflator	2 (9)	NA	4 (9)	NA	2 (9)	NA	1 (9)	NA	1 (8)	NA
Unemployment Rate	2^{T}(9)	NA	3^{T}(9)	NA	5 (9)	NA	6 (9)	NA	6 (8)	NA
Outside Sample										
Current Dollar GNP	1 (8)	1 (7)	1 (8)	1 (7)	1 (8)	1 (7)	1 (8)	1 (7)	1 (6)	1 (6)
Constant Dollar GNP	1 (8)	1 (7)	1 (8)	1 (7)	1 (8)	1 (7)	1 (8)	1 (7)	1 (6)	1 (6)
GNP Deflator	1 (8)	NA	1 (8)	NA	1 (8)	NA	3^{T}(8)	NA	6 (6)	NA
Unemployment Rate	6 (8)	NA	6 (8)	NA	6 (8)	NA	6 (8)	NA	4 (6)	NA

Notes: 1. NA = Not Available.

2. A superscript ^{T} denotes a tie.

3. The two annual models and the one monthly model considered in Fromm and Klein [26] were excluded from the rankings because of lack of comparability.

4. The number in parentheses for each rank is the number of models used for the ranking. A complete set of results was not available for every model.

5. The eight other models are (1) BEA (Bureau of Economic Analysis), (2) Brookings, (3) DHL III (University of Michigan), (4) DRI-71 (Data Resources, Inc.), (5) Federal Reserve Bank of St. Louis, (6) MPS (University of Pennsylvania), (7) Wharton Mark III (University of Pennsylvania), (8) Wharton Mark III Anticipations Version.

6. The within sample prediction period was 1961I–1967IV for all models except Brookings and the forecasting model. For Brookings the period was 1959I–1965IV, and for the forecasting model the period was 1962I–1967IV.

uous in indicating that the forecasting model is the most accurate of the models, they certainly do indicate that the model is at least no less accurate than any of the other models. Another encouraging set of results about the forecasting model is presented in Fair [13], where the ex ante forecasting performance of the model is examined for the 1970III–1973II period. The results in [13] indicate that the ex ante forecasts from the model, which are never subjectively adjusted before being released, are nearly (but not quite) as accurate as subjective ex ante forecasts.[a] The model appears to be the first model that can be used in a mechanical way and produce reasonably accurate results.

Although, as mentioned in the previous section, the ex ante performance of a model cannot be used in a rigorous way to evaluate its accuracy, the result just cited is at least encouraging as to the model's accuracy. This is especially true in the present case because the results in [13] also show that the forecasting accuracy of the model would generally have been improved had the actual values of the exogenous variables been known (rather than guessed) at the time the forecasts were made. This latter conclusion is certainly what one would expect from a model, but, as discussed in [13], it does not appear to be true of other models. If the forecasting accuracy of a model is not generally improved when actual values of exogenous variables are substituted for guessed values, this both indicates the important role that subjective adjustments play in the release of the ex ante forecasts and, unless the differences are fairly small, calls into question the basic accuracy of the model.

There are some negative results regarding the accuracy of the forecasting model that have occurred since the evaluation in [13] was completed. The model does not predict 1973 and 1974 nearly as well as it predicts earlier years. This is true of both the ex ante forecasts that have been released by me and the ex post forecasts that have been generated since the data on the exogenous variables for 1973 and 1974 became available. The three equations that perform the worst for 1973 and 1974 are the price equation, the inventory equation, and the import equation.

The price equation substantially underpredicts the inflation that occurred during 1973 and 1974, and the inventory and import equations do not capture very well the large changes in inventory investment and imports that occurred during these years. The other equations of the model appear to have held up much better during 1973 and 1974. Their coefficient estimates for the most part have not changed very much as the observations for 1973 and 1974 have been added to the sample period, and the residual estimates for the quarters of 1973 and 1974 are not noticeably larger than the estimates for earlier quarters.

The 1973–1974 period is not an easy period to predict, and it appears to be the case that other models also do not predict this period nearly as well as they predict earlier periods. The periods considered for the results in Fromm and Klein [26] do not include 1973 and 1974, and at the time of this writing there are no similar comparisons of the models for the 1973–1974 period. It is thus unknown whether the predictive accuracy of my forecasting model deteriorated more in 1973 and 1974 than it did for other models. The conclusion of this section is thus that the forecasting model appears to be at least as accurate as other models for the period prior to 1973, but that it is unknown whether this result is also true for the 1973–1974 period.

Because of the uncertainty as to whether the accuracy of the forecasting model deteriorated more in 1973 and 1974 than it did for other models and because the poorer performance of the forecasting model in 1973 and 1974 can be traced in large part to the price, inventory, and import equations, it was decided for the comparison of the empirical model and the forecasting model in the next section to drop these three equations from the forecasting model. The price level, inventory investment, and imports were thus taken to be exogenous in the forecasting model. The empirical model was not changed, so that these three variables remained endogenous in the empirical model.

This procedure clearly biases the results in favor of the forecasting model and thus provides a more stringent test of the empirical model. If the empirical model is more accurate than this less endogenous version of the forecasting model, then the conclusion that the empirical model is also more accurate than other models can be held with more confidence than it could be if the empirical model were merely more accurate than the complete version of the forecasting model. Although it may be that the complete version of the forecasting model is less accurate than other models for the 1973–1974 period, it seems unlikely that the less endogenous version is also less accurate.

8.3 A COMPARISON OF THE EMPIRICAL MODEL AND THE FORECASTING MODEL

For a comparison of the predictive accuracy of two models to be fair, the prediction periods should be the same for both models, and both models should be of the same degree of endogeneity. Requiring the prediction periods to be the same rules out the obvious possibility that one model will perform better than another merely because of an easier prediction period used. Requiring the models to be of the same degree of endogeneity rules out the possibility of one model performing better merely because it treats important endogenous variables as exogenous. One model should not treat as exogenous any variable that the other model treats as endogenous and that most people would agree is in fact truly endogenous.

It is also desirable if possible for the predictions to be outside sample and dynamic. Requiring the predictions to be outside sample rules out the possibility of a model performing well merely because of much diligence on the part of a model builder in getting her or his model to fit the estimation period well. This requirement, in other words, lessens the possibility that a model will perform well merely because of data mining. Since lagged endogenous variables play an important role in most macroeconometric models, requiring the predictions to be dynamic provides a good way of testing whether the dynamic structure of the economy has been captured adequately in the model.

The empirical model and the complete version of the forecasting model are not of the same degree of endogeneity. Both take government variables, population, and exports as exogenous, but the forecasting model also takes as exogenous the mortgage rate, deposit flows into Savings and Loan Associations and Mutual Savings Banks, a consumer sentiment variable, and a variable measuring plant and equipment investment expectations. The empirical model takes as exogenous relative prices and the price of imports, which are not part of the forecasting model and therefore not taken as exogenous.

Overall, it is clear that the forecasting model is of a lesser degree of endogeneity than is the empirical model. This is, of course, even more true for the less endogenous version of the forecasting model. The following comparison of the empirical model and the forecasting model is thus not ideal, even though all the other requirements discussed above have been met, and, as discussed at the end of the previous section, one should consider the comparison as being somewhat biased in favor of the forecasting model.

The empirical model was estimated through 1974II. Data through 1975I were collected for this study, and so there are three quarters available for outside sample comparisons. Two prediction periods were considered for the comparisons in this section: a within sample period of 46 observations (1963I–1974II) and the outside sample period of 3 observations (1974III–1975I). The estimates of the forecasting model that were used for the results in this section are presented in Appendix B to this volume. The forecasting model was also estimated through 1974II to put it on a comparable basis with the empirical model. Both static and dynamic predictions were generated for the two models.

The accuracy of the two models is compared in Table 8–2. The table is fairly self-explanatory, and so the following is only a brief discussion of the results. Consider first the static, within sample results. For these results the two models are quite similar. The forecasting model is slightly more accurate with respect to predictions of current dollar GNP, but some-

Table 8–2. The Predictive Accuracy of the Empirical Model versus the Forecasting Model

EM = Empirical Model, TSLS Estimates
FM = Forecasting Model with Inventory Investment, Imports, and the Price Level Exogenous
RMSE = Root Mean Square Error of Level Predictions
*RMSE*Δ = Root Mean Square Error of First Difference Predictions

		1963I–1974II (*within sample*) *DYNAMIC*				1963I–1974II (*within sample*) *STATIC*		1974III–1975I (*outside sample*) *DYNAMIC*				1974III–1975I (*outside sample*) *STATIC*	
		RMSE		*RMSE*Δ		*RMSE*		*RMSE*		*RMSE*Δ		*RMSE*	
Variable in EM	*Variable in FM*	*EM*	*FM*	*EM*	*FM*	*EM*	*FM*	*EM*	*FM*	*EM*	*FM*	*EM*	*FM*
GNP_t	GNP_t	9.10	9.87	7.60	5.47	5.19	5.09	10.64	26.84	12.85	25.95	6.83	23.87
Y_t	$GNPR_t$	9.12	7.74	5.20	4.13	3.66	3.84	5.95	15.59	7.66	15.35	6.12	14.01
$100 \cdot UR_t$	$100 \cdot UR_t$	0.437	0.860	0.264	0.234	0.227	0.262	0.760	0.982	0.745	0.742	0.374	0.667
$PCS_t CS_t$	CS_t	4.55	1.24	1.50	1.15	1.21	1.11	2.78	3.55	1.99	3.33	2.05	3.19
$PCN_t CN_t$	CN_t	3.62	7.59	2.12	2.31	1.76	2.25	1.68	3.46	2.68	4.62	2.92	4.93
$PCD_t CD_t$	CD_t	4.23	3.21	3.09	2.60	2.37	2.44	7.73	12.67	12.19	14.97	11.79	13.76
$PIH_t IH_t$	IH_t	3.78	2.85	2.76	1.30	1.36	0.89	9.86	9.41	6.28	4.76	5.20	3.22
TLF_{1t}	LF_{1t}	77.	104.	51.	50.	51.	50.	132.	189.	184.	203.	166.	201.
TLF_{2t}	LF_{2t}	827.	296.	215.	209.	182.	193.	488.	370.	294.	249.	237.	264.
$MOON_t$	D_t	314.	336.	242.	254.	211.	235.	130.	96.	124.	121.	59.	203.
$PFF_t INV_t$	IP_t	2.26	3.06	1.33	1.46	1.44	1.41	3.83	7.42	2.29	4.01	2.22	4.25
$JOBF_t$	M_t	1126.	909.	257.	269.	235.	248.	459.	806.	582.	758.	436.	660.
$EMPL_t$	E_t	966.	730.	285.	249.	234.	224.	540.	876.	670.	868.	492.	755.

Note: See Appendix B for a definition of the variables in the forecasting model. Root mean square errors for flow variables are at *annual* rates.

what less accurate with respect to predictions of constant dollar GNP and the unemployment rate. For the components of current dollar GNP, the empirical model does worst relative to the forecasting model with respect to the predictions of housing investment, which reflects in large part the fact that the forecasting model takes the mortgage rate and deposit flows into Savings and Loan Associations and Mutual Savings Banks as exogenous. Somewhat surprisingly, the two models are of about the same degree of accuracy with respect to predictions of plant and equipment investment, even though the forecasting model takes plant and equipment investment expectations as exogenous.

Consider next the dynamic, within sample results in Table 8–2. The discussion here will concentrate on the RMSE results. The empirical model is slightly more accurate with respect to predictions of current dollar GNP, somewhat less accurate with respect to predictions of constant dollar GNP, and considerably more accurate with respect to predictions of the unemployment rate. Even though the forecasting model is less accurate with respect to predictions of the unemployment rate, it is more accurate with respect to predictions of the level of employment ($EMPL_t$ or E_t) and the level of nonprime-age-male labor force (TLF_{2t} or LF_{2t}). With respect to the components of GNP, the empirical model is better for nondurable consumption and plant and equipment investment and worse for service consumption, durable consumption, and housing investment.

Consider finally the outside sample results in Table 8–2. It is obvious from these results that the empirical model is more accurate than the forecasting model for the outside sample period considered here. The three quarters that comprise this period are not easy quarters to predict, and the empirical model clearly does a better job in predicting them than does the forecasting model. When the forecasting model is made more endogenous by adding back in, in various combinations, the price, inventory, and import equations, the results are worse than those presented in Table 8–2. Consequently, the poorer results for the forecasting model in Table 8–2 are not due to an unfortunate exclusion of equations that cause the overall model to be less accurate than it would be if the equations were not excluded.

Although the outside sample results are based on only three observations, the overall results in Table 8–2 clearly indicate that the empirical model is more accurate than the forecasting model. The within sample results are about the same for the two models, and the outside sample results are considerably better for the empirical model. Since the forecasting model appears from the results in the previous section to be at least as accurate as other models, the tentative conclusion here is that the empirical model is more accurate than other models. This conclusion is tentative because of the uncertainty as to whether even the less endogenous version of the forecasting model is as accurate as other models for the 1973–1974 period. Clearly more comparisons are needed before any definitive conclusions can be drawn. It should be noted, however, that even if it turns out that the less endogenous version of the forecasting model is less accurate than other models for the 1973–1974 period, it may still be the case that the empirical model is more accurate. The empirical model is substantially more accurate than the forecasting model for the outside sample results in Table 8–2, not just marginally so.

8.4 FURTHER RESULTS ON THE PREDICTIVE ACCURACY OF THE EMPIRICAL MODEL

The purpose of this section is to consider the predictive accuracy of the empirical model in somewhat more detail. Two of the questions considered in this section are how the accuracy of the model estimated by TSLS compares to the accuracy of the model estimated by FIML, and how accurate the model is during recessionary periods and other hard-to-forecast periods.

Results that are relevant to answering the first question are presented in Table 8–3. Two prediction periods are considered in the table: a within sample period of 82 observations (1954I–1974II) and the outside sample period of 3 observations (1974III–1975I)[b]. Results for both static and dynamic predictions and for both the TSLS and FIML estimates are presented in the table. The results in Table 8–3 are again fairly self-explanatory, and the discussion here will only highlight some of the more interesting ones.

First, a comparison of the TSLS and FIML results in the table yields no obvious winner. The results are generally fairly close for the two sets of estimates, and there are no strong grounds for arguing that one set of results is better than the other. One would, of course, expect the results to be fairly close because of the closeness of the TSLS and FIML estimates themselves. As discussed in Chapter Three, it is not clear how close the FIML estimates obtained in this study are to the true FIML estimates, and so the FIML results in Table 8–3 must be interpreted with some caution. It may be, as the results in Table 8–3 indicate, that the predictive accuracy of the model is about the same for both the TSLS and FIML estimates, but one should probably reserve judgment on this until further experimentation is done on trying to obtain true FIML estimates of the model.

Consider next the accuracy of the model regarding the predictions of the bill rate. For the TSLS results, the root mean square errors of the level predictions of the bill rate range from 1.81 percentage points for the static, within sample results to 4.14 percentage points for the dynamic,

Table 8–3. Further Results on the Predictive Accuracy of the Empirical Model

FIML = FIML Estimates Used
TSLS = TSLS Estimates Used
RMSE = Root Mean Square Error of Level Predictions
*RMSE*Δ = Root Mean Square Error of First Difference Predictions

Equation No. in Table 2–2	Variable	1954I–1974II (within sample) DYNAMIC				1954I–1974II (within sample) STATIC		1974III–1975I (outside sample) DYNAMIC				1974III–1975I (outside sample) STATIC	
		RMSE		*RMSE*Δ		*RMSE*		*RMSE*		*RMSE*Δ		*RMSE*	
		FIML	*TSLS*	*FIML*	*TSLS*	*FIML*	*TSLS*	*FIML*	*TSLS*	*FIML*	*TSLS*	*FIML*	*TSLS*
10.	Y_t	8.15	6.24	5.88	6.28	3.45	3.47	5.88	5.95	6.40	7.66	6.16	6.12
9.	PF_t	0.0156	0.0147	0.0060	0.0056	0.0051	0.0049	0.0046	0.0097	0.0063	0.0086	0.0052	0.0016
	GNP_t	7.84	9.71	7.30	8.03	4.90	4.93	7.88	10.64	10.23	12.85	6.20	6.83
83.	UR_t	0.574	0.529	0.352	0.356	0.240	0.238	0.945	0.760	0.737	0.745	0.462	0.374
70.	$RBILL_t$	3.04	2.59	2.91	3.03	1.84	1.81	4.75	4.14	6.44	6.48	4.26	2.97
1.	CS_t	6.81	4.20	1.23	1.09	0.81	0.80	2.27	1.13	1.23	1.15	1.57	1.29
2.	CN_t	5.43	4.65	1.42	1.42	1.23	1.22	1.39	1.45	2.48	2.55	2.01	2.03
46.	CD_t	2.78	2.56	2.68	2.62	1.83	1.84	6.53	6.16	9.52	9.98	9.60	9.29
47.	IH_t	3.12	3.26	2.62	3.37	1.13	1.12	4.70	4.88	2.57	2.98	2.77	2.53
5.	TLF_{1t}	169.	132.	65.	65.	58.	58.	129.	132.	183.	184.	165.	166.
6.	TLF_{2t}	462.	407.	258.	253.	221.	223.	362.	488.	234.	294.	222.	237.
7.	$MOON_t$	319.	292.	256.	258.	218.	219.	102.	130.	105.	124.	60.	59.
8.	DDH_t	3.92	3.27	2.70	2.35	1.75	1.70	5.53	7.67	2.91	4.32	2.35	2.89
11.	INV_t	2.00	1.71	1.00	0.96	0.96	0.95	2.09	2.31	1.03	1.18	1.25	1.24
12.	$JOBF_t$	876.	691.	319.	310.	264.	263.	594.	459.	613.	582.	497.	436.
13.	HPF_t	2.04	1.97	1.99	1.97	1.56	1.55	2.68	2.33	1.23	1.16	1.97	2.01
14.	$HPFO_t$	3.09	3.04	2.29	2.37	2.59	2.60	3.41	3.46	4.00	4.24	3.30	3.31

15.	WF_t	0.60	0.98	0.24	0.25	0.26	0.26	0.54	0.79	0.37	0.41	0.35	0.38
16.	DDF_t	2.20	1.98	0.84	0.80	0.68	0.69	0.17	0.23	0.17	0.27	0.20	0.12
17.	$DIVF_t$	4.70	3.18	0.48	0.44	0.38	0.38	0.42	0.50	0.67	0.43	0.49	0.41
18.	$INTF_t$	6.89	6.49	0.46	0.45	0.32	0.32	0.89	1.25	0.67	0.89	0.28	0.32
19.	IVA_t	4.09	3.83	5.41	5.24	3.71	3.67	16.59	16.11	17.56	18.79	17.84	16.29
20.	$BORR_t$	0.97	0.86	0.65	0.64	0.49	0.51	2.22	2.12	2.56	2.65	2.46	2.18
21.	$RAAA_t$	0.85	0.81	0.81	0.80	0.48	0.47	1.07	1.27	1.50	1.93	0.96	0.86
22.	$RMORT_t$	0.79	0.72	0.66	0.62	0.19	0.19	0.51	0.43	0.63	0.51	0.89	0.86
23.	CG_t	310.	309.	540.	533.	213.	211.	696.	816.	848.	1009.	585.	587.
24.	IM_t	1.48	1.46	0.93	0.93	0.80	0.80	4.14	3.96	3.35	3.19	3.36	3.36
25.	TPU_t	0.57	0.50	0.35	0.36	0.35	0.35	2.99	2.59	2.74	2.75	1.66	1.37
26.	$INTG_t$	1.22	1.05	0.55	0.50	0.39	0.38	0.48	0.84	0.84	1.06	0.62	0.54
45.	BR_t	0.87	0.63	0.56	0.48	0.34	0.33	0.99	1.44	0.51	0.78	0.41	0.52
48.	X_t	7.83	5.93	5.14	5.67	3.18	3.15	7.33	7.12	12.13	12.65	12.35	12.11
51.	$V_t - V_{t-1}$	3.05	3.10	3.33	3.39	2.51	2.47	6.68	6.88	10.87	11.12	7.95	7.68
52.	πF_t	7.99	7.30	8.97	9.46	6.12	5.88	19.46	19.97	15.50	18.56	16.85	12.95
53.	CF_t	6.34	5.81	4.08	4.92	3.11	2.96	11.31	10.59	16.46	14.77	15.06	14.94
55.	LF_t	40.74	38.46	1.64	1.53	0.97	0.97	2.90	3.33	3.37	3.28	4.31	4.24
58.	YH_t	9.42	11.56	3.57	3.62	3.33	3.38	9.45	12.90	10.64	11.52	7.84	8.89
60.	$SAVH_t$	8.10	7.47	4.74	5.62	3.00	2.89	11.97	13.17	12.47	12.96	11.75	10.96
61.	A_t	104.83	97.19	76.41	76.49	52.43	51.96	175.88	208.13	173.50	202.79	146.70	146.72
62.	DDB_t	4.74	3.46	3.10	2.65	1.83	1.81	5.41	7.88	2.95	4.55	2.15	2.77
64.	$LBVBB_t$	3.69	2.99	2.44	2.07	1.48	1.47	5.67	6.81	3.59	4.49	3.65	3.52
65.	$SAVR_t$	1.78	1.78	1.27	1.27	1.06	1.05	9.80	10.27	8.01	7.83	7.83	8.15
67.	TAX_t	4.47	4.69	4.94	5.24	3.26	3.24	10.88	10.94	11.77	13.38	10.20	9.09
68.	$SAVG_t$	3.85	3.65	4.48	4.79	2.61	2.62	10.33	11.09	11.26	13.10	9.26	8.53
81.	$EMPL_t$	721.	597.	305.	320.	236.	246.	685.	540.	683.	670.	545.	492.
82.	U_t	422.	394.	259.	263.	187.	185.	883.	717.	679.	688.	417.	333.

Note: Root mean square errors for flow variables are at *annual* rates.

outside sample results. Given the way the bill rate is determined in the model, these errors seem fairly reasonable, although they are by no means as small as one might hope.

I thought in the initial phases of this study that the FIML estimates would lead to more accurate predictions of the bill rate than would the TSLS estimates. As mentioned in Chapter Three, the FIML estimator does not require that there be a natural left-hand side variable for each equation, and since there is no equation in which the bill rate appears naturally as a left-hand side variable, the FIML estimator appears to be the natural estimator to use for the model. Since the FIML estimator, unlike the TSLS estimator, takes into account in an explicit way the fact that the bill rate is implicitly determined in the model, one might expect the predictions of the bill rate to be more accurate for the FIML estimates than for the TSLS estimates. This unfortunately is not the case for the results in Table 8–3. Again, however, this may be due to a failure to obtain estimates that are close to the true FIML estimates, and so one should probably reserve judgment on this issue as well until more experimentation is done.

The FDYN estimator discussed in Chapter Three also takes into account the fact that the bill rate is implicitly determined in the model, and if in future work it is possible to obtain FDYN estimates of the model, it will be of interest to see if these estimates lead to more accurate predictions of the bill rate than have been obtained so far.

Two final points about the results in Table 8–3 will be made here. First, the accuracy with which the model predicts $SAVR_t$ is the accuracy with which it predicts the U.S. balance of payments on current account. The RMSEs for $SAVR_t$ in Table 8–3 range from about a billion dollars (at an annual rate) for the static, within sample results to about ten billion dollars for the dynamic, outside sample results. Second, the accuracy with which the model predicts $SAVG_t$ is the accuracy with which it predicts the budget deficit or surplus of the government. The RMSEs for $SAVG_t$ range from about three billion dollars to about ten billion dollars. The RMSEs for $SAVG_t$ are always quite close to the RMSEs for the total net tax collections of the government (TAX_t).

Results that pertain to the question of the accuracy of the model during hard-to-predict periods are presented in Tables 8–4, 8–5, and 8–6. The three periods considered in these tables are 1955I–1962IV, which encompasses the 1958 and 1960 recessions; 1968I–1974II, which encompasses the 1970 recession and the beginning of the 1974 recession; and 1974III–1975I, which is the outside sample period considered in Tables 8–2 and 8–3. The period between 1962IV and 1968I was not considered because it is a period of fairly smooth growth.

The results in Tables 8–4 and 8–5 are taken from the dynamic simulation using the TSLS estimates that began in 1954I. The predictions in these two tables are within sample predictions. The results in Table 8–6 are taken from the dynamic simulation using the TSLS estimates that began in 1974III. The predictions in this table are outside sample predictions. Predictions for five variables are presented in the tables: Y_t, PF_t, GNP_t, UR_t, and $RBILL_t$. Again, the results in the three tables are fairly self-explanatory, and the following discussion will only highlight a few of them.

There is no question that the model stays roughly on track over time. The model ends the dynamic 82-quarter simulation in 1974II (Table 8–5) with an error for Y_t of only 11.2 billion dollars and an error for the unemployment rate of only 0.51 percentage points. The error for the price level is -0.025, or about -1.8 percent. The fact that the model ends the simulation in this way means that any large errors that it might make along the way tend to get corrected over time.

Consider now the results in Table 8–4 and concentrate on those quarters in which the error in predicting Y_t is greater than 10.0 billion dollars in absolute value. The first such quarter is 1958I. Y_t decreased by 18.1 billion dollars from 1957III to 1958I (from 406.8 to 388.7), whereas the model predicted a decrease of only 7.0 billion dollars (from 406.9 to 399.9). The prediction error in 1958I, the trough for Y_t, is 11.2 billion dollars. The model predicted the trough for Y_t to occur two quarters later than it did. The predicted value of Y_t for this quarter (1958III) is 392.4 billion dollars, which compares closely to the actual trough value of 388.7 billion dollars. The model thus caught the magnitude of the 1958 recession fairly well, but missed some of the timing.

Regarding the predictions of the unemployment rate during the 1958 recession, the model had it peaking in 1958III at 7.24 percent, which compares to the actual peak a quarter earlier of 7.38 percent. The bill rate predictions for 1958I and 1958II are both much too high. The prediction for 1958II is 7.77 percent, which compares to the actual rate of only 1.02 percent. There are a number of quarters in Tables 8–4, 8–5, and 8–6 in which very large errors are made in predicting the bill rate, and 1958I and 1958II are clearly two of them.

The next large errors for Y_t occur in 1959IV and 1960I, where errors of 19.2 and 13.8 billion dollars are made. The economy is difficult to predict for 1959IV and 1960I because of the effects of the 1959 steel strike, and not much importance should be attached to the results for these two quarters.

The model caught the 1960 recession about as well as it caught the 1958 recession. Y_t reached a trough of 429.2 billion dollars in 1961I. The model predicted the trough to occur a quarter later. The predicted value of Y_t for this quarter (1961II) is 429.7 billion dollars, which compares almost exactly to the actual trough value of 429.2 billion dollars. The model predicted the unemployment rate very well during this period. The unemploy-

Table 8–4. Predicted and Actual Values for Five Variables for the 1955I–1962IV Period

Dynamic Predictions Using TSLS Estimates
Prediction Period Began in 1954I
P = Predicted Value
A = Actual Value
$E = P - A$

	Y_t			PF_t			GNP_t			$100 \cdot UR_t$			$RBILL_t$		
Quarter	*P*	*A*	*E*	*P*	*A*	*E*	*P*	*A*	*E*	*P*	*A*	*E*	*P*	*A*	*E*
1955I	380.1	381.7	−1.6	0.825	0.825	0.000	385.6	386.2	−0.6	4.73	4.75	−0.02	0.36	1.26	−0.90
II	391.2	389.3	1.9	0.828	0.825	0.003	398.0	394.4	3.6	3.98	4.42	−0.44	0.68	1.61	−0.93
III	395.8	395.7	0.1	0.830	0.831	−0.001	402.8	402.5	0.3	3.61	4.15	−0.54	0.85	1.86	−1.01
IV	400.3	399.7	0.6	0.831	0.839	−0.008	406.8	408.7	−2.0	3.38	4.25	−0.87	0.57	2.35	−1.78
1956I	405.9	397.2	8.7	0.841	0.846	−0.004	417.5	410.6	6.9	3.12	4.07	−0.96	3.30	2.38	0.93
II	404.8	398.1	6.7	0.849	0.851	−0.002	421.8	416.2	5.6	3.23	4.23	−1.00	3.82	2.60	1.23
III	402.5	397.3	5.2	0.857	0.859	−0.002	424.9	420.7	4.3	3.68	4.17	−0.49	6.16	2.60	3.57
IV	399.1	403.0	−3.9	0.860	0.867	−0.008	422.2	429.4	−7.2	4.35	4.14	0.21	1.79	3.06	−1.27
1957I	409.3	405.5	3.7	0.868	0.880	−0.012	435.5	437.2	−1.7	4.29	3.99	0.30	2.50	3.17	−0.67
II	410.5	405.0	5.5	0.878	0.883	−0.005	442.7	439.7	2.9	4.26	4.10	0.15	5.55	3.16	2.39
III	406.9	406.8	0.0	0.885	0.889	−0.004	444.3	446.2	−1.9	4.75	4.25	0.50	4.55	3.38	1.17
IV	406.1	399.6	6.5	0.892	0.894	−0.002	446.0	441.4	4.6	5.47	4.96	0.51	5.15	3.34	1.81

1958I	399.9	388.7	11.2	0.898	0.896	0.002	445.6	434.8	10.8	6.23	6.30	−0.07	5.90	1.84	4.06
II	395.3	390.2	5.1	0.905	0.897	0.008	446.3	438.6	7.8	6.84	7.38	−0.54	7.77	1.02	6.75
III	392.4	401.3	−8.9	0.898	0.901	−0.003	441.0	451.6	−10.6	7.24	7.33	−0.09	0.60	1.71	−1.11
IV	410.8	411.9	−1.1	0.901	0.906	−0.006	460.8	464.4	−3.5	6.57	6.38	0.19	1.25	2.79	−1.53
1959I	419.1	418.7	0.4	0.899	0.912	−0.013	468.1	473.9	−5.9	5.90	5.83	0.07	0.88	2.80	−1.92
II	430.1	430.2	−0.1	0.899	0.915	−0.016	479.2	486.6	−7.4	5.20	5.14	0.07	1.22	3.02	1.80
III	430.8	423.4	7.4	0.885	0.919	−0.034	475.5	483.8	−8.3	6.04	5.32	0.72	0.07	3.53	−3.46
IV	448.6	429.4	19.2	0.902	0.920	−0.019	500.7	490.2	10.5	4.95	5.62	−0.68	9.60	4.30	5.30
1960I	452.9	439.1	13.8	0.908	0.922	−0.014	509.9	502.9	7.0	5.29	5.19	0.10	11.89	3.94	7.95
II	428.8	437.0	−8.2	0.906	0.924	−0.018	487.3	504.7	17.4	6.09	5.26	0.83	2.19	3.09	−0.90
III	437.5	435.0	2.5	0.909	0.925	−0.015	499.6	504.2	−4.6	6.65	5.58	1.07	2.07	2.39	−0.32
IV	443.0	430.7	12.2	0.917	0.928	−0.011	510.2	503.2	7.0	6.51	6.28	0.23	6.66	2.36	4.30
1961I	438.2	429.2	9.0	0.924	0.929	−0.005	509.7	503.6	6.1	6.60	6.80	−0.20	9.09	2.38	6.71
II	429.7	439.6	−9.9	0.924	0.931	−0.007	501.0	514.9	−13.9	7.07	6.99	0.07	2.28	2.32	−0.04
III	441.8	447.8	−6.1	0.918	0.930	−0.012	512.3	524.2	−11.9	6.71	6.77	−0.07	0.42	2.32	−1.91
IV	452.8	457.2	−4.4	0.924	0.934	−0.010	527.9	537.7	−9.8	5.75	6.20	−0.45	2.30	2.48	−0.18
1962I	461.8	464.3	−2.5	0.925	0.935	−0.010	539.9	547.8	−8.0	5.20	5.64	−0.44	2.57	2.74	−0.17
II	475.3	472.0	3.2	0.930	0.938	−0.008	556.0	557.2	−1.2	4.83	5.51	−0.68	5.01	2.72	2.29
III	478.0	476.9	1.1	0.936	0.939	−0.003	563.2	564.4	−1.2	4.96	5.57	−0.61	8.23	2.86	5.38
IV	478.7	482.2	−3.6	0.936	0.942	−0.006	564.8	571.9	−7.2	5.49	5.54	−0.05	3.05	2.80	0.25

Notes: Values for Y_t and GNP_t are at annual rates.
E does not always equal $P - A$ in the table because of rounding.

Table 8–5. Predicted and Actual Values for Five Variables for the 1968I–1974II Period

Dynamic Predictions Using TSLS Estimates
Prediction Period Began in 1954I
P = Predicted Value
A = Actual Value
$E = P - A$

Quarter	Y_t P	Y_t A	Y_t E	PF_t P	PF_t A	PF_t E	GNP_t P	GNP_t A	GNP_t E	$100 \cdot UR_t$ P	$100 \cdot UR_t$ A	$100 \cdot UR_t$ E	$RBILL_t$ P	$RBILL_t$ A	$RBILL_t$ E
1968I	613.5	622.3	−8.9	1.057	1.053	0.004	826.5	834.0	−7.5	3.66	3.77	−0.10	4.62	5.06	−0.44
II	627.2	633.9	−6.6	1.055	1.062	−0.007	845.1	857.4	−12.3	3.40	3.58	−0.18	0.77	5.51	−4.74
III	639.4	640.0	−0.6	1.069	1.071	−0.002	873.3	875.2	−1.9	2.83	3.55	−0.72	4.93	5.23	−0.30
IV	647.1	644.3	2.8	1.072	1.082	−0.011	887.0	890.2	−3.2	2.78	3.43	−0.66	1.88	5.58	−3.70
1969I	654.5	650.1	4.3	1.088	1.093	−0.005	908.9	906.9	2.1	2.56	3.42	−0.86	6.01	6.14	−0.13
II	653.1	652.8	0.4	1.098	1.105	−0.007	919.3	923.5	−4.2	2.77	3.46	−0.69	5.84	6.24	−0.40
III	655.9	655.4	0.5	1.109	1.118	−0.009	936.5	941.8	−5.3	3.11	3.63	−0.52	8.46	7.05	1.41
IV	656.0	651.5	4.5	1.119	1.130	−0.011	946.5	948.9	−2.4	3.60	3.62	−0.02	6.55	7.32	−0.76
1970I	652.5	647.5	5.0	1.131	1.143	−0.012	956.5	958.5	−2.1	4.23	4.19	0.04	9.21	7.26	1.94
II	651.8	647.7	4.2	1.137	1.155	−0.018	963.2	970.6	−7.4	4.87	4.76	0.11	4.01	6.75	−2.74
III	657.5	653.0	4.6	1.148	1.164	−0.016	981.0	987.4	−6.3	5.21	5.20	0.01	4.24	6.37	−2.13
IV	653.6	644.8	8.7	1.158	1.185	−0.027	983.2	991.8	−8.6	5.60	5.84	−0.24	4.90	5.36	−0.46
1971I	669.8	662.4	7.5	1.164	1.195	−0.031	1014.0	1027.8	−13.9	5.64	5.96	−0.33	2.78	3.86	−1.09
II	677.0	667.1	9.9	1.174	1.207	−0.033	1034.3	1047.3	−13.0	5.46	5.92	−0.47	4.56	4.21	0.36
III	687.6	671.2	16.4	1.185	1.215	−0.030	1058.7	1061.3	−2.6	5.39	5.97	−0.58	6.43	5.05	1.38
IV	693.4	682.5	10.9	1.196	1.216	−0.021	1080.4	1083.2	−2.8	5.53	5.97	−0.45	7.75	4.23	3.51
1972I	694.5	694.3	0.2	1.204	1.232	−0.028	1090.6	1115.0	−24.4	5.81	5.82	−0.01	5.14	3.44	1.70
II	704.3	709.8	−5.5	1.208	1.237	−0.029	1110.8	1143.0	−32.2	5.97	5.68	0.29	1.68	3.75	−2.06
III	719.4	720.7	−1.3	1.214	1.244	−0.030	1142.6	1169.3	−26.7	5.65	5.56	0.08	1.24	4.24	−3.00
IV	739.7	736.1	3.6	1.228	1.253	−0.025	1186.6	1204.7	−18.1	5.05	5.31	−0.26	3.55	4.85	−1.30

1973I	758.6	754.9	3.7	1.239	1.264	−0.025	1232.8	1248.9	−16.1	4.58	4.99	−0.42	2.87	5.64	−2.77
II	764.0	758.4	5.5	1.261	1.281	−0.020	1267.5	1277.9	−10.3	4.28	4.91	−0.63	5.44	6.61	−1.17
III	759.2	762.0	−2.8	1.289	1.298	−0.009	1297.5	1308.9	−11.3	4.64	4.76	−0.12	12.37	8.39	3.98
IV	759.3	766.6	−7.4	1.310	1.328	−0.018	1316.6	1344.0	−27.5	5.13	4.75	0.38	2.97	7.46	−4.49
1974I	766.0	751.3	14.7	1.352	1.374	−0.022	1361.0	1358.8	2.2	5.28	5.14	0.14	7.02	7.60	−0.58
II	758.7	747.6	11.2	1.399	1.424	−0.025	1380.7	1383.8	−3.1	5.65	5.15	0.51	10.27	8.27	2.00

Notes: See notes to Table 8–4.

Table 8–6. Predicted and Actual Values for Five Variables for the 1974III–1975I Period

Dynamic Predictions Using TSLS Estimates
Prediction Period Began in 1974III
P = Predicted Value
A = Actual Value
$E = P - A$

	Y_t			PF_t			GNP_t			$100 \cdot UK_t$			$RBILL_t$		
Quarter	*P*	*A*	*E*	*P*	*A*	*E*	*P*	*A*	*E*	*P*	*A*	*E*	*P*	*A*	*E*
1974III	734.5	743.5	−8.9	1.469	1.468	0.000	1404.8	1416.3	−11.5	5.85	5.51	0.34	8.41	8.29	0.12
IV	722.5	724.0	−1.5	1.501	1.515	−0.014	1417.8	1430.9	−13.1	6.49	6.60	−0.10	2.60	7.34	−4.74
1975I	703.6	698.7	4.9	1.546	1.555	−0.009	1422.5	1416.6	5.9	7.08	8.35	−1.27	11.26	5.87	5.38

Notes: See notes to Table 8–4.

ment rate reached a peak of 6.99 percent in 1961II, which compares almost exactly to the predicted peak in the same quarter of 7.07 percent.

Consider next the results in Table 8–5. The first errors for Y_t of greater than 10.0 billion dollars occur in 1971III and 1971IV. The model predicted that Y_t would increase more in the last half of 1971 than it actually did. The model was back on track in 1972I, however, and it stayed fairly much on track until 1974I, where it failed to predict the decrease in Y_t that occurred in that quarter. The unemployment rate predictions are all fairly good in Table 8–5. All the errors are less than a percentage point, with the largest error of 0.86 percentage points occurring in 1969I. The largest value of the bill rate for the period considered in this study is 8.39 percent in 1973III, and it is interesting to note that the largest predicted value of the bill rate also occurs in this quarter, 12.37 percent.

All the errors in predicting the price level in Table 8–5 are negative except for the first one. The errors are not, however, particularly large. The largest error occurs in 1971II (−0.033), where the actual value is about 2.8 percent larger than the predicted value. The largest three errors in predicting the *rate* of inflation in Table 8–5 occur in 1968II, 1970IV, and 1973III. The actual rates in these three quarters (at an annual rate) are 3.5 percent, 7.4 percent, and 5.4 percent, respectively, while the predicted rates are −0.8 percent, 3.5 percent, and 9.2 percent, respectively.

The final predictions to consider are the ones in Table 8–6. These predictions are outside sample predictions for a fairly difficult period, and so they provide a good test of the model. Y_t decreased by 48.9 billion dollars from 1974II to 1975I (from 747.6 to 698.7). The model predicted a decrease in this period of 44.2 billion dollars (from 747.6 to 703.6). Not a bad prediction. The price level increased at an annual rate of 12.5 percent in this three-quarter period (from 1.424 to 1.555). The model predicted an increase of 11.6 percent (from 1.424 to 1.546). Not bad again. This is clearly a remarkable performance by the model given the extreme behavior of the economy during this period and the fact that the predictions are outside sample predictions.

The unemployment rate increased from 5.15 percent in 1974II to 8.35 in 1975I. The model predicted an increase to 7.08 percent in 1975I, and so it underpredicted the increase by 1.27 percentage points. The model predicted the bill rate almost exactly in 1974III, but it underpredicted the bill rate by 4.74 percentage points in 1974IV and overpredicted the bill rate by 5.38 percentage points in 1975I.

This completes the examination of the predictive accuracy of the model. While some of the above discussion has concentrated on the more negative results, the overall performance of the model appears quite good. There are only a few cases in which the model does not appear capable of tracking well the quarter-to-quarter performance of the economy. The outside sample predictions for 1974III, 1974IV, and 1975I in Table 8–6 are particularly encouraging regarding the model's accuracy. The predictions of the bill rate are clearly in the most need of improvement. At times very large errors are made by the model in predicting the bill rate. As mentioned above, these errors may be lessened by the use of estimates like FIML and FDYN, but as of now this is only a conjecture.

NOTES

[a]The results of the two studies of McNees [34], [35], are consistent with this conclusion. The ex ante performance of the model is not generally as good as the ex ante performance of the other (subjectively adjusted) models, but it is not too far below the others.

[b]Regarding the 1954I–1974II period, data on one endogenous variable, $HPFO_t$, are only available beginning in 1956I. Since $HPFO_t$ is endogenous and enters the model only contemporaneously, the lack of data on $HPFO_t$ causes no problem except in computing its error measure. For purposes of computing RMSE and RMSEΔ for $HPFO_t$ in Table 8–3 for the 82-observation period, the predictions of $HPFO_t$ for the first eight quarters (1954I–1955IV) were compared to the single-equation predicted values of $HPFO_t$ generated from Equation 14 in Table 2–3 using the actual values of HPF_t.