11 Tests of Different Versions of the Model and the Properties of the Final Version

11.1 Introduction

In this chapter the phrase "version of the model" is used to refer to a particular set of estimated equations. The word "model" is used rather loosely to refer to the set of all of the versions considered. One of the advantages of a small-scale model such as the present one is that different versions of it can be readily tested, and in this chapter the results of testing the different versions of the model will be discussed.

The procedure that has been used to test each version will be discussed in Section 11.2, and the error measures that have been used will be discussed in Section 11.3. The results of testing the different versions will then be examined in Section 11.4, and the final version will be presented in tabular form in Section 11.5. Finally, the properties of the final version of the model will be examined in detail in Section 11.6.

11.2 The Procedure Used to Test Each Version

Using the matrix notation in Chapter 2, the money GNP sector of the model can be written as:

$$AY + BX = U, \tag{11.1}$$

$$U = RU_{-1} + E. \tag{11.2}$$

Y is the matrix of endogenous variables, X is the matrix of predetermined variables, U and E are matrices of error terms, and A, B, and R are coefficient matrices. Since there are eight endogenous variables in the money GNP sector, (11.1) consists of eight equations, one of which is the income identity. The reduced form for each of the eight endogenous variables can be derived from (11.1) and (11.2). Since U_{-1} equals $AY_{-1} + BX_{-1}$,

$$AY + BX = RAY_{-1} + RBX_{-1} + E, \tag{11.3}$$

or

$$Y = -A^{-1}BX + A^{-1}RAY_{-1} + A^{-1}RBX_{-1} + A^{-1}E. \tag{11.4}$$

(11.4) consists of eight equations, each equation being the reduced form equation for one of the endogenous variables. The expression for Y in (11.4) is the same as the expression (2.10) in Chapter 2.

From the results in Chapters 3–7, estimates of the coefficients in A, B, and R are available. Many of the coefficients are, of course, known a priori to be zero, one, or minus one. Using the estimates of A, B, and R; assuming E to be zero; and given values for the predetermined variables, X, for the lagged endogenous variables, Y_{-1}, and for the lagged predetermined variables, X_{-1}, predictions of each of the endogenous variables can be made from (11.4). It should be remembered that some lagged endogenous variables are included among the predetermined variables in X. This means that these variables are included in both X and Y_{-1}. For example, CS_{t-1} is included in both X and Y_{-1} (since CS_{t-1} is an explanatory variable in the equation explaining CS_t), whereas IP_{t-1} is included only in Y_{-1} (IP_{t-1} enters the reduced form (11.4) only because of the serial correlation in the equation explaining IP_t).

Different versions of the model correspond to different estimates of A, B, and R, as well as perhaps to different predetermined variables in X. The question arises as to how the different versions of the model should be tested. One obvious test of the accuracy of each version is to derive within the sample period the reduced form predictions for each endogenous variable and to compare these predictions with the actual values. These reduced form predictions are similar to one-period forecasts of the endogenous variables, since the actual values of the lagged endogenous variables are assumed to be known for each prediction.

Howrey and Kelejian [27] have shown that for purposes of validating an econometric model no additional information beyond that already contained in the reduced form results can be gained by simulating the model within the sample period and comparing the simulated values with the actual values. "Simulation" here refers to the procedure of generating predictions from equations like (11.4) using generated values of the lagged endogenous variables as opposed to the actual values. "Validation" refers to the procedure of testing the hypothesis that the model is a true representation of the structure it is designed to explain. While Howrey and Kelejian's conclusion holds for purposes of validation, it does not apply to the testing procedure that is of concern here. The question that arises here is not which version of the model is the best representation of the structure of the economy, but rather which version generates the best forecasts; and for purposes of answering this question simulation results are likely to be of help. For multiperiod forecasting purposes, error accumulation is important, and simulating the different versions of the model for the length of the forecast period should indicate the degree to which each of the versions is sensitive to this accumulation—something that the reduced form results could not indicate.

This question of whether the model should be simulated is related to the discussion in Chapter 2 about what kind of techniques should be used when estimating forecasting models. As Klein and others have pointed out, the classical techniques such as ordinary least squares or two-stage least squares are based on the assumption that the actual values of the lagged endogenous variables are known, which is contrary to the situation that exists in multiperiod forecasting. Since, as pointed out in Chapter 2, the estimating techniques that might be used for forecasting models are complicated to use and not as yet well understood, the technique that was used in this study is based on the classical assumption of known values of the lagged endogenous variables. Notice, however, that if simulation results are used in the choice of the final version of the model, the overall procedure of estimating and choosing the final version cannot be considered to rest completely on the assumption of known values of the lagged endogenous variables. Presumably those versions that are sensitive to error accumulation will be eliminated by the simulation tests. The procedure used here can thus perhaps be considered to be a first approximation to a more general procedure for estimating multiperiod forecasting models.

In addition to the reduced form (one-period) predictions, then, each of the versions of the model was simulated for five quarters at a time (with the base period being increased by one quarter after each five-quarter forecast), and the simulated values of the endogenous variables were compared with the actual values. (Five quarters was chosen, somewhat arbitrarily, as the length of the forecasting horizon.) For all of these simulations the actual values of the exogenous variables were used. The prediction period that was used for the simulations and for the reduced form predictions was from 602 through 694, excluding 644, 651, and 652. The last three quarters were excluded from the prediction period since they were omitted from the periods of estimation because of the automobile strike. The reason this shorter period was used instead of the period beginning in 561 was the unavailability of some of the data before 1959. The 602 quarter was chosen as the starting point because the observations for 593, 594, and 601 were omitted from the periods of estimation because of the steel strike. Using this prediction period, there were thus a total of 36 quarters for which one-quarter-ahead (reduced form) forecasts could be made, 34 quarters for which two-quarter-ahead forecasts could be made, 32 quarters for which three-quarter-ahead forecasts could be made, 30 quarters for which four-quarter-ahead forecasts could be made, and 28 quarters for which five-quarter-ahead forecasts could be made. All of the forecasts considered in this chapter were within-sample forecasts, i.e., all of the equations tested were estimated through 694.

So far in this chapter attention has been concentrated on the money GNP sector of the model. The money GNP sector is the only sector for which extensive simulation tests were made in order to choose the final equations of the sector. The equations in the monthly housing starts sector, the employment and labor force sector, and the price sector were chosen primarily by looking at the properties of the estimated equations. There is no simultaneity within or between these sectors, and so there is less of a need to examine the equations in simulation before making the final choices. Nevertheless, the entire model was simulated when the money GNP sector was being tested, and all of the equations were examined to make sure that none of them were giving unexpected results.

The simulations were performed as follows. The two monthly housing starts equations were first used to generate predictions of monthly housing starts. Lagged housing starts enter both equations through the serial correlation of the error terms; and in the demand equation, lagged housing starts also enter through the housing stock variable After the one-month-ahead prediction, generated values of lagged housing starts were used, rather than the actual values. The two housing starts equations were weighted equally, and the housing starts prediction for any one month was taken to be the average of the predictions from the two equations for that month. The generated values of lagged housing starts for use in both equations were taken from the average of the two predictions, and not from the separate predictions of the two equations.

The monthly housing starts predictions were used to construct predictions of quarterly (seasonally adjusted) housing starts to be used in the money GNP sector. The money GNP sector was then simulated in the manner described above, using the predicted values of the quarterly housing starts variable rather than the actual values. With respect to the generation of the values for the lagged endogenous variables, it should be noted that there are two-quarter-lagged values of some of the endogenous variables in the X_{-1} matrix in (11.4). For these cases the actual values of the variables were used for the two-quarter-ahead forecast, and only beginning with the three-quarter-ahead forecast were the generated values used. It should also be noted that lagged values of the quarterly housing starts variable are included in the X and X_{-1} matrices in (11.4). Again, the actual values of these variables were used until the appropriate time came to switch to using the predictions from the monthly housing starts sector.

The money GNP predictions were used in the price sector to generate predictions of the private output deflator and real GNP (government output being taken to be exogenous). Taking farm output to be exogenous, predictions of real private nonfarm output could then be made, and these predictions were used in the employment and labor force sector to generate predictions of man-hour requirements and then private nonfarm employment. The employment predictions were then used to generate predictions of the labor force, and from these predictions, predictions of the unemployment rate were made. In the price and employment and labor force sectors, lagged values of the endogenous variables were treated in the same way as described above for the money GNP sector. Lagged endogenous variables enter all of the equations in the employment and labor force sector, since all of the equations have been estimated under the assumption of first order serial correlation of the error terms.

The one problem that arose in simulating the model was how to treat the quarters, 684, 691, 692, and 693, which were affected by the dock strike. The dock strike had little effect on net exports and thus on GNP, but it had a pronounced effect on exports and imports individually. As mentioned in Chapter 2, the 684–693 quarters were omitted from the sample period for the import equation, and the export variable was not used as an instrument in estimating any of the equations. In simulating the model through the 684–693 period, the following procedure was followed with respect to exports and imports. The level of exports was 53.4 billion dollars in 683 and 57.8 billion dollars in 693 (at annual rates). The change from 683 to 693 was thus 4.4 billion dollars. An *adjusted* export series was constructed in which the level of exports was taken to change by 1.1 billion dollars in each of the four quarters, 684–693. This adjusted series was then used in place of the actual series for the simulations.

With respect to imports, the level of imports was 49.7 billion dollars in 683 and 55.2 billion dollars in 693, for a change of 5.5 billion dollars. An *adjusted* import series was thus constructed in which the level of imports was taken to change by 1.3 billion dollars in 684 and 1.4 billion dollars in each of the other three quarters, 691–693. The import equation was then allowed to simulate through the 684–693 period, with the only difference being that for the one-quarter-ahead forecast (for which the actual value of lagged imports is required), the "actual" value of lagged imports was taken to be the adjusted value.

The treatment of exports and imports in this way will have little effect on the predictions of GNP and its other components, which is consistent with the small effect that the dock strike had on actual GNP and its other components. Looking at this in another way, in an actual forecasting situation, assuming no knowledge of the dock strike, the import equation would have been used in the model in the normal way and exports would have been assumed to increase by about one billion dollars a quarter, which is consistent with the procedure that was followed for the simulations.

11.3 The Error Measures Used

There are a number of error measures that can be used when comparing the predicted values of the endogenous variables with their actual values. Two obvious ones are the mean absolute error and the root mean square error. Let y_{it} denote the actual value of variable y_i for period t and let y_{pit} denote the predicted value of variable y_i for period t. Then the mean absolute error for y_i is

$$\text{MAE}_i = \frac{1}{T} \sum_{t=1}^{T} |y_{it} - y_{pit}|, \tag{11.5}$$

where T is the number of observations for the prediction period. The root mean square error for y_i is

$$\text{RMSE}_i = \sqrt{\frac{1}{T} \sum_{t=1}^{T} (y_{it} - y_{pit})^2}. \tag{11.6}$$

For purposes of judging the accuracy of short-term forecasting models, how well the model forecasts changes in the endogenous variables may be of more importance than how well it forecasts levels. Errors made in terms of levels may tend to compound over time, whereas this is less likely to be true for errors in terms of changes. If, for example, a model substantially overpredicted the one-quarter-ahead change, but was quite accurate in forecasting the next four quarterly changes, the level error measures as in (11.5) and (11.6) would penalize the model for the two-, three-, four-, and five-quarter-ahead forecasts more heavily than would seem warranted by the nature of the error that was made. Equations (11.5) and (11.6) can be expressed in terms of changes rather than levels:

$$\text{MAE}\Delta_i = \frac{1}{T} \sum_{t=1}^{T} |(y_{it} - y_{it-1}) - (y_{pit} - y_{pit-1})|, \tag{11.7}$$

$$\text{RMSE}\Delta_i = \sqrt{\frac{1}{T} \sum_{t=1}^{T} [(y_{it} - y_{it-1}) - (y_{pit} - y_{pit-1})]^2}. \tag{11.8}$$

MAEΔ denotes the mean absolute error in terms of changes, and RMSEΔ denotes the root mean square error in terms of changes. For one-quarter-ahead forecasts, y_{it-1} and y_{pit-1} are the same (the actual values of the lagged endogenous variables are known), and thus for these forecasts, MAEΔ and RMSEΔ in (11.7) and (11.8) are the same as MAE and RMSE in (11.5) and (11.6) respectively.

Whether the MAE criterion, the RMSE criterion, or some other error criterion should be used depends on one's welfare or loss function. The mean absolute error is perhaps easiest to interpret, and it is the error measure that has been used here. The root mean square errors were also computed in this study, and in general they lead to the same conclusions as did the mean absolute errors.

In computing MAE and MAEΔ for imports, the 684–693 period was excluded, since the errors made during this period (either predicted minus actual imports or predicted minus adjusted imports) were in some sense artificial. For the error measures for the other variables, the 684–693 period was not excluded, and it should be noted that the "actual" GNP series that was used in computing the GNP error measures was the published series and not the series that could have been constructed using the adjusted export and import series.

11.4 The Results of Testing Each Version

The eight equations that were tested are presented in Table 11–1. There were two equations tested for durable consumption, two for nondurable consumption, two for inventory investment, and two for imports. The two durable consumption equations differ in that the second one was estimated over the shorter sample period and includes the Bureau of Census buying expectations variable, $ECAR_{t-2}$, in place of one of the lagged values of the Michigan Survey Research Center consumer sentiment variable, $MOOD_{t-2}$. The two nondurable consumption equations differ in that the first one was estimated over the shorter sample period. The two inventory investment equations differ in that the second one includes GNP_t as an explanatory variable rather than $CD_{t-1} + CN_{t-1}$. Finally, the two import equations differ in that the second one includes the lagged GNP variable.

Since there are two possible equation choices for four different endogenous variables, this means that there are $2^4 = 16$ different versions of the model to consider. Each of the 16 versions was simulated in the manner described above, and MAE and MAEΔ were calculated for each of the endogenous variables for the one-, two-, three-, four-, and five-quarter-ahead forecasts

Table 11–1. The Equations Tested in this Chapter. (The first equation for each variable is the one chosen for the final version of the model.)

Equation		$\hat{\rho}$	SE	$R\Delta^2$	No. of Obser-vations
(3.1)	$CD_t = -25.43 + .103\widehat{GNP}_t + .110MOOD_{t-1} + .092MOOD_{t-2}$ (4.22) (39.78) (1.88) (1.54)	.648 (6.01)	1.125	.554	50
(3.2)	$CD_t = -32.09 + .105\widehat{GNP}_t + .164MOOD_{t-1} + .084ECAR_{t-2}$ (4.38) (35.33) (2.35) (1.64)	.456 (3.08)	1.155	.527	36
(3.7)	$CN_t = .081\widehat{GNP}_t + .646CN_{t-1} + .147MOOD_{t-2}$ (5.40) (9.30) (4.67)	−.381 (2.47)	1.383	.550	36
(3.8)	$CN_t = .034\widehat{GNP}_t + .866CN_{t-1} + .049MOOD_{t-2}$ (3.50) (19.71) (2.50)	−.320 (2.47)	1.436	.402	50
(6.15)	$V_t - V_{t-1} = -114.76 + .728(CD_{t-1} + CN_{t-1}) - .357V_{t-1}$ (4.09) (4.27) (3.94) $+ .095(CD_{t-1} + CN_{t-1} - \widehat{CD}_t - \widehat{CN}_t)$ (0.42)	.791 (9.15)	2.540	.589	50
(6.18)	$V_t - V_{t-1} = -94.48 + .241\widehat{GNP}_t - .368V_{t-1}$ (5.66) (6.25) (5.88) $- .568(\widehat{CD}_t + \widehat{CN}_t - CD_{t-1} - CN_{t-1})$ (5.04)	.882 (13.24)	1.927	.763	50
(7.3)	$IMP_t = .078\widehat{GNP}_t$ (8.70)	1.0	.637	.437	45
(7.1)	$IMP_t = .050\widehat{GNP}_t + .030GNP_{t-1}$ (2.09) (1.31)	1.0	.608	.499	45

over the relevant prediction periods.[1] These errors were then examined for the various versions, with special emphasis being placed on the errors made in forecasting total GNP and on the errors made in forecasting beyond one or two quarters. When comparing two different equations for the same endogenous variable, all of the other equations remaining the same, emphasis was also placed on the errors made in forecasting that particular variable.

The procedure of selecting the final version of the model was of necessity somewhat subjective, but the final choice was not too difficult. Almost all of the results were unambiguous in the sense that an equation that performed better than another when one set of the remaining equations was used also performed better when other sets were used. There appeared, in other words, to be little simultaneous interacting of errors. Also, a version that gave better one- and two-quarter-ahead forecasts than another also tended to give better three-, four-, and five-quarter-ahead forecasts. There was thus no dilemma involved in having to choose between one- and two-quarter-ahead forecasting accuracy and three-, four-, and five-quarter-ahead accuracy.

The major difficulty that arose in analyzing the test results was due to the fact that the above tests are biased in favor of the equations that were estimated using the period of estimation beginning in 602 instead of the longer period beginning in 561. Equations that were estimated using the shorter period would be expected to give better results when tested for the same period than equations that were estimated using the longer period but tested for the shorter period. If one felt that a structural change had taken place beginning about 1960, then he would be justified in using the shorter period of estimation exclusively; otherwise more efficient estimates can be achieved using the longer estimation period. When comparing two equations that were estimated using the different periods of estimation, the results that were achieved using the equation estimated for the shorter period were discounted to some extent.

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[1] As mentioned in Section 11.3, MAE and MAEΔ are the same for the one-quarter-ahead forecasts. For the two- through five-quarter-ahead forecasts, computing MAE is straightforward: the forecasted levels are merely compared with the actual levels. There may be some confusion in how MAEΔ was computed for the two- through five-quarter-ahead forecasts, however, and this is worth elaborating on. Let $y_{pit}^{(j)}$ denote the j-quarter-ahead forecast of y_i for quarter t (the forecast being made in quarter $t-j$), and let y_{it} continue to denote (as above) the actual value of y_i for quarter t. Then MAEΔ for the j-quarter-ahead forecast is

$$\frac{1}{T}\sum_{T=1}^{T} |(y_{it} - y_{it-1}) - (y_{pit}^{(j)} - y_{pit-1}^{(j-1)})|,$$

where $y_{pit-1}^{(j-1)}$ is the $(j-1)$-quarter-ahead forecast of y_i for quarter $t-1$. The forecasts $y_{pit}^{(j)}$ and $y_{pit-1}^{(j-1)}$ are made at the same time (in quarter $t-j$), and so the difference in these two forecasts is *the j-quarter-ahead forecast of the change in y_i for quarter t.*

Turning first to the nondurable consumption equations in Table 11–1, the choice between equation (3.7), which was estimated for the shorter sample period, and equation (3.8), which was estimated for the longer period, was fairly easy. The results using equation (3.7) were consistently better, many times by a fairly wide margin; and in particular the errors made by using equation (3.8) tended to compound much more.[2] Even considering the bias in favor of equation (3.7) because it was estimated for the shorter period, the results still seemed to indicate that equation (3.8) should not be accepted. In other words, the results seemed to indicate that there has been a shift in the relationship specified in the nondurable equation between 1956 and 1960. Equation (3.7) was thus chosen as the basic equation explaining the consumption of nondurables.

For durable consumption the choice was more difficult. Equation (3.2), which was estimated for the shorter sample period and which includes the consumer buying expectations variable of the Bureau of the Census, in general gave slightly better results in terms of the level errors and slightly poorer results in terms of the change errors than did equation (3.1). Considering the slight bias in favor of equation (3.2) because it was estimated for the shorter sample period, the results were quite close, and there was little to choose between the two equations. Either equation could have been included in the final version of the model. Equation (3.1) was chosen for the final version for two main reasons. First, it was based on more observations, which, other things being equal, is a desirable property to have. Secondly, using equation (3.1) in the final version meant the $ECAR_{t-2}$ did not have to be included among the final exogenous variables of the model, which meant that there was one less exogenous variable to forecast ahead of the overall forecast. Since the desire was to keep the model as simple as possible and since the *MOOD* series would have been used in the model even if equation (3.2) had been chosen, it seemed natural to choose equation (3.1) over (3.2) and lessen by one the number of exogenous variables in the model. This would not have been done had the use of equation (3.2) led to noticeably better results.

With respect to the import equations, equation (7.3), which does not include the lagged GNP variable, appeared to give slightly better results than did equation (7.1). In terms of the level errors the results were quite close, but in terms of the change errors the results achieved using equation

[2] For example, the nondurable consumption mean absolute errors in terms of levels for the one- through five-quarter-ahead forecasts were 1.11, 1.34, 1.46, 1.41, and 1.37 billion dollars respectively when equation (3.7) was used (all other equations of the final version being used) and were 1.15, 1.49, 1.79, 1.74, and 1.75 billion dollars respectively when equation (3.8) was used (again, all other equations of the final version being used).

(7.3) were marginally better. Equation (7.3) was thus chosen as the equation determining the level of imports, but either equation would have been satisfactory for this purpose.

With respect to the inventory investment equation, the results were quite interesting. The choice was between equation (6.18), which includes GNP_t as an explanatory variable, and equation (6.15), which includes $CD_{t-1} + CN_{t-1}$ instead. Note in Table 11–1 that the fit of equation (6.18) is noticeably better than the fit of equation (6.15) (SE = 1.927 vs. 2.540). In order to examine in some detail the simulation results achieved using the two equations, the mean absolute errors for GNP and inventory investment are presented in Table 11–2 for the two equations. The other equations

Table 11–2. Comparison of Equations (6.15) and (6.18).
(Errors presented for GNP_t and $V_t - V_{t-1}$ only.)

Length of Forecast	Variable	No. of Observations	MAE for (6.15)	MAE for (6.18)	MAEΔ for (6.15)	MAEΔ for (6.18)
One quarter ahead	GNP_t	36	2.34	2.63	same	
One quarter ahead	$V_t - V_{t-1}$	36	1.87	1.98		
Two quarters ahead	GNP_t	34	3.37	3.36	2.24	2.47
Two quarters ahead	$V_t - V_{t-1}$	34	2.63	2.46	2.78	2.81
Three quarters ahead	GNP_t	32	3.18	3.43	2.34	2.58
Three quarters ahead	$V_t - V_{t-1}$	32	2.61	2.32	3.04	3.12
Four quarters ahead	GNP_t	30	2.91	3.34	2.32	2.51
Four quarters ahead	$V_t - V_{t-1}$	30	2.47	2.20	3.17	3.12
Five quarters ahead	GNP_t	28	3.09	3.31	2.36	2.52
Five quarters ahead	$V_t - V_{t-1}$	28	2.20	1.86	3.21	3.23

that were used for the results presented in Table 11–2 are the equations that were included in the final version of the model, namely the equations listed first for each variable in Table 11–1.

Comparing the results in Table 11–2, the use of equation (6.15) clearly leads to better results in terms of forecasting GNP. For the one-quarter-ahead forecast, for example, the mean absolute error for GNP was 2.34 billion dollars using equation (6.15) versus 2.63 billion dollars using equation (6.18). Likewise, for the five-quarter-ahead forecast the error was 3.09 using equation (6.15) versus 3.31 using equation (6.18). Even though the fit of equation (6.18), which includes GNP_t as an explanatory variable, is considerably better than the fit of equation (6.15), the use of equation (6.18) led to poorer simulation results in terms of predicting GNP. In terms of predicting inventory investment, equation (6.18) performed slightly better with respect to predicting the level of inventory investment (aside from the one-quarter-ahead forecast) and about the same with respect to predicting the change in inventory investment. The use of equation (6.15) has thus resulted in slightly more error cancellation with respect to predicting GNP.

It is encouraging that equation (6.15), which is based on stronger theoretical grounds, performed so well in simulation. The better fit of equation (6.18) thus appears to be misleading, even though the two-stage least squares technique was used to estimate the equation. Equation (6.15) was thus chosen as the final equation determining inventory investment—a choice that may not have been made had not the model been simulated to determine the final equation.

This completes the discussion of the tests of the various versions. In practice many more versions than those described above were tested during the development of the model, but the choice appeared to narrow down to one of the above versions. In general, the kinds of tests described in this section appeared to be worth the costs involved in performing them. There were enough surprises—such as the better performance of equation (6.15) relative to equation (6.18)—to indicate that one should not attempt to choose equations without first testing them within the context of the overall model.

11.5 The Final Version of the Model

The variables that are used in the final version of the model are listed in Table 11–3 in alphabetical order by sector. The equations of the final version are listed in Table 11–4 by sector. There are fourteen behavioral equations in the model, one production function, and six identities. There are four basic exogenous variables in the monthly housing starts sector (not counting

Table 11–3. Variables of the Model in Alphabetical Order by Sector.

The Monthly Housing Starts Sector	
†$DHF3_t$	= Three-month moving average of the flow of advances from the Federal Home Loan Bank to Savings and Loan Associations in millions of dollars
†DI_t	= Dummy variable I for month t, $I = 1, 2, \ldots, 11$
†$DSF6_t$	= Six-month moving average of private deposit flows into Savings and Loan Associations and Mutual Savings Banks in millions of dollars
HS_t	= Private nonform housing starts in thousands of units
†RM_t	= FHA mortgage rate series on new homes in units of 100
†W_t	= Number of working days in month t
†$/\Delta RM_t/$	= [see equation (8.21)]
†$\backslash\Delta RM_t\backslash$	= [see equation (8.22)]

Table 11-3 (cont.)

The Money GNP Sector	
CD_t	= Consumption expenditures for durable goods, SAAR
CN_t	= Consumption expenditures for nondurable goods, SAAR
CS_t	= Consumption expenditures for services, SAAR
†EX_t	= Exports of goods and services, SAAR
†G_t	= Government expenditures plus farm residential fixed investment, SAAR
GNP_t	= Gross National Product, SAAR
HSQ_t	= Quarterly nonfarm housing starts, seasonally adjusted at quarterly rates in thousands of units
IH_t	= Nonfarm residential fixed investment, SAAR
IMP_t	= Imports of goods and services, SAAR
IP_t	= Nonresidential fixed investment, SAAR
†$MOOD_t$	= Michigan Survey Research Center index of consumer sentiment in units of 100
†$PE2_t$	= Two-quarter-ahead expectation of plant and equipment investment, SAAR
$V_t - V_{t-1}$	= Change in total business inventories, SAAR
The Price Sector and the Employment and Labor Force Sector	
†AF_t	= Level of the armed forces in thousands
D_t	= Difference between the establishment employment data and household survey employment data, seasonally adjusted in thousands of workers
E_t	= Total civilian employment, seasonally adjusted in thousands of workers
†GG_t	= Government output, SAAR
$GNPR_t$	= Gross National Product, seasonally adjusted at annual rates in billions of 1958 dollars
†$GNPR_t^*$	= Potential GNP, seasonally adjusted at annual rates in billions of 1958 dollars
LF_{1t}	= Level of the primary labor force (males 25–54), seasonally adjusted in thousands
LF_{2t}	= Level of the secondary labor force (all others over 16), seasonally adjusted in thousands
M_t	= Private nonfarm employment, seasonally adjusted in thousands of workers
†MA_t	= Agricultural employment, seasonally adjusted in thousands of workers
†MCG_t	= Civilian government employment, seasonally adjusted in thousands of workers
$M_t H_t$	= Man-hour requirements in the private nonfarm sector, seasonally adjusted in thousands of man-hours per week
†P_{1t}	= Noninstitutional population of males 25–54 in thousands
†P_{2t}	= Noninstitutional population of all others over 16 in thousands
PD_t	= Private output deflator, seasonally adjusted in units of 100
UR_t	= Civilian unemployment rate, seasonally adjusted
Y_t	= Private nonfarm output, seasonally adjusted at annual rates in billions of 1958 dollars
†YA_t	= Agricultural output, seasonally adjusted at annual rates in billions of 1958 dollars
†YG_t	= Government output, seasonally adjusted at annual rates in billions of 1958 dollars

Notes: † Exogenous variable.
SAAR = Seasonally adjusted at annual rates in billions of current dollars.

the dummy variables), four exogenous variables in the money GNP sector (not counting the quarterly housing starts variable), and nine exogenous variables in the price and employment and labor force sectors.

The causality in the model has been described previously and will not be elaborated on here. It should be remembered that the quarterly housing starts variable, HSQ_t, is exogenous in the money GNP sector, but is endogenous in the overall model. Likewise, money GNP is exogenous in the price sector, but is endogenous in the overall model; and private nonfarm output is exogenous in the employment and labor force sector, but is endogenous in the overall model.

Two points about error cancellation in the model should be mentioned. The first point is that errors in one direction in predicting durable and nondurable consumption should lead to errors in the opposite direction in predicting inventory investment: as can be seen in equation (6.15) in Table 11–4, current inventory investment and current durable and nondurable consumption are inversely related. These offsetting errors will then lead to smaller errors in predicting total GNP. The second point about error cancellation relates to the employment and labor force sector and was touched on briefly in Chapter 9. As can be seen from equations (9.9) and (9.10), errors in predicting private nonfarm employment, M_t, will lead to errors in the same direction in predicting the D_t variable, which will in turn lead to smaller errors in predicting total civilian employment, E_t. Likewise, errors in predicting E_t lead in equation (9.12) to errors in the same direction in predicting the secondary labor force, LF_{2t}, which will in turn lead to smaller errors in equation (9.14) in predicting the unemployment rate.

11.6 The Properties of the Final Version

The Quarterly Results

It can be seen from the results for equation (6.15) in Table 11–2 that the simulation errors for GNP are quite small. The largest mean absolute error in terms of levels is 3.37 billion dollars (for the two-quarter-ahead forecast), and the largest mean absolute error in terms of changes is 2.36 billion dollars (for the five-quarter-ahead forecast). The results in Table 11–2 cannot be used to compare how the accuracy of the forecasts varies with the length of the forecast period because the results for each of the five quarterly forecasts are based on a different prediction period. In order to make this comparison, the mean absolute errors for the one-, two-, three-, and four-quarter-ahead forecasts were computed for the same prediction period (28 observations)

Table 11–4. Equations of the Model by Sector.

Equation		$\hat{r}$	SE	$R\Delta^2$	No. of observations
	The Monthly Housing Starts Sector				
(8.23)*	$HS_t = \sum_{l=1}^{11} \hat{d}_l DI_t + 2.70W_t + 112.95 - .0709 \sum_{i=1}^{t-1} HS_i + 8.48t$ (4.63) (2.46) (2.27) (2.31) $-.127RM_{t-2} - .412/\Delta RM_t/$ (1.45) (2.81)	.841 (17.54)	8.98	.790	127
(8.24)*	$HS_t = \sum_{l=1}^{11} \hat{d}'_l DI_t + 2.84W_t - 49.22 - .164t + .0541DSF6_{t-1} + .0497DHF3_{t-2}$ (4.42) (1.75) (2.63) (8.07) (5.27) $+ .100RM_{t-1} - .412\backslash\Delta RM_t\backslash$ (2.67) (2.81)	.507 (6.64)	8.30	.822	127
	The Money GNP Sector				
(3.3)	$CD_t = -25.43 + .103\widehat{GNP}_t + .110MOOD_{t-1} + .092MOOD_{t-2}$ (4.22) (39.78) (1.88) (1.54)	.648 (6.01)	1.125	.554	50
(3.7)	$CN_t = .081\widehat{GNP}_t + .646CN_{t-1} + .147MOOD_{t-2}$ (5.40) (9.30) (4.67)	−.381 (2.47)	1.383	.550	36
(3.11)	$CS_t = .022\widehat{GNP}_t + .945CS_{t-1} - .023MOOD_{t-2}$ (4.15) (47.77) (7.37)	−.077 (0.55)	.431	.891	50
(4.4)	$IP_t = -8.50 + .063\widehat{GNP}_t + .687PE2_t$ (4.86) (8.87) (8.34)	.689 (6.72)	1.011	.633	50
(5.5)	$IH_t = -3.53 + .016\widehat{GNP}_t + .0242HSQ_t + .0230HSQ_{t-1} + .0074HSQ_{t-2}$ (2.31) (13.12) (5.37) (4.45) (1.66)	.449 (3.01)	.582	.792	36

Table 11–4 (contd.)

Equation		$\hat{r}$	SE	$R\Delta^2$	No. of Observations
	The Money GNP Sector				
(6.15)	$V_t - V_{t-1} = -114.76 + .728(CD_{t-1} + CN_{t-1}) - .357V_{t-1}$ (4.09) (4.27) (3.94)				
	$+ .095(CD_{t-1} + CN_{t-1} - \widehat{CD}_t - \widehat{CN}_t)$ (0.42)	.791 (9.15)	2.540	.589	50
(7.3)	$IMP_t = .078\widehat{GNP}_t$ (8.70)	1.0	.637	.437	45
Income identity	$GNP_t = CD_t + CN_t + CS_t + IP_t + IH_t + V_t - V_{t-1} - IMP_t + EX_t + G_t$				
	The Price Sector				
(10.5)	$GAP2_t = GNPR_t^* - GNPR_{t-1} - (GNP_t - GNP_{t-1})$				
(10.7)‡	$PD_t - PD_{t-1} = -1.037 + 165.76 \dfrac{1}{78.36 + \frac{1}{8}\sum_{i=1}^{8} GAP2_{t-i+1}}$ (1.44) (1.19) (2.00)	0	.183	.810	50
(10.8)	$GNPR_t = 100 \dfrac{GNP_t - GG_t}{PD_t} + YG_t$				
(10.9)	$Y_t = GNPR_t - YA_t - YG_t$				

(9.2)	$M_tH_t = \frac{1}{\alpha_t} Y_t$				
(9.8)‡	$\log M_t - \log M_{t-1} = -.514 + .0000643t - .140(\log M_{t-1} - \log M_{t-1}H_{t-1})$ (3.44) (1.57) (3.41) $+ .121(\log Y_{t-1} - \log Y_{t-2}) + .298(\log Y_t - \log Y_{t-1})$ (2.34) (6.43)	.336 (2.52)	.00310	.778	50
(9.10)	$D_t = 13014 - 71.10t + .358M_t$ (8.23) (6.15) (9.39)	.600 (5.30)	181.4	.460	50
(9.9)	$E_t = M_t + MA_t + MCG_t - D_t$				
(9.11)	$\frac{LF_{1t}}{P_{1t}} = .981 - .000190t$ (652.38) (8.57)	.265 (1.94)	.00193	.447	50
(9.12)	$\frac{LF_{2t}}{P_{2t}} = .180 + .000523t + .447 \widehat{\frac{E_t + AF_t}{P_{1t} + P_{2t}}}$ (2.69) (4.97) (3.67)	.797 (9.32)	.00228	.373	50
(9.14)	$UR_t = 1 - \frac{E_t}{LF_{1t} + LF_{2t} - AF_t}$				

* $\hat{d}_I$ and $\hat{d}_I'$ values are presented in Chapter 8.

‡ The R-squared is computed taking the dependent variable to be in the form listed on the left-hand side of the equation rather than in the change in this form.

as was used for the five-quarter-ahead forecasts. The results for 15 of the endogenous variables of the model are presented in Table 11–5. All of the quarterly endogenous variables that are explained by behavioral (stochastic) equations have been included in the table, as well as three of the endogenous variables that are explained by identities: money GNP, real GNP, and the unemployment rate.

From the results in Table 11–5 it can be seen that there is a tendency for

Table 11–5. Errors for the Final Version of the Model Computed for the Same Prediction Period.

	Variable	Length of Forecast One Quarter Ahead	Two Quarters Ahead	Three Quarters Ahead	Four Quarters Ahead	Five Quarters Ahead	No. of Observa-tions
MAE							
	GNP_t	1.99	2.53	2.16	2.33	3.09	28
	CD_t	.83	1.01	1.11	1.22	1.25	28
	CN_t	1.14	1.24	1.38	1.37	1.37	28
	CS_t	.31	.45	.57	.71	.79	28
	IP_t	.84	.93	.98	1.11	1.17	28
	IH_t	.53	.73	.85	.87	.87	28
	$V_t - V_{t-1}$	1.85	2.39	2.21	2.20	2.20	28
	IMP_t	.55	.77	1.06	1.21	1.25	24
	PD_t	.12	.20	.26	.30	.31	28
	$GNPR_t$	1.92	2.46	2.43	2.36	2.43	28
	M_t	130	241	321	378	372	28
	D_t	175	210	217	239	241	28
	LF_{1t}	48	52	52	52	52	28
	LF_{2t}	196	280	294	323	336	28
	UR_t	.0017	.0023	.0031	.0035	.0040	28
MAEΔ							
	GNP_t	1.99	1.94	2.34	2.35	2.36	28
	CD_t	.83	.93	.95	.92	.98	28
	CN_t	1.14	1.19	1.20	1.25	1.29	28
	CS_t	.31	.32	.32	.31	.31	28
	IP_t	.84	.83	.89	.85	.89	28
	IH_t	.53	.63	.68	.67	.69	28
	$V_t - V_{t-1}$	1.85	2.85	3.13	3.21	3.21	28
	IMP_t	.55	.50	.49	.48	.48	24
	PD_t	.12	.12	.12	.12	.13	28
	$GNPR_t$	1.92	1.86	2.12	2.07	2.12	28
	M_t	130	179	141	146	160	28
	D_t	175	182	184	181	186	28
	LF_{1t}	48	53	54	55	55	28
	LF_{2t}	196	199	197	195	198	28
	UR_t	.0017	.0015	.0014	.0014	.0015	28

the errors in terms of levels to compound as the forecast horizon lengthens. For money GNP and real GNP there is only a very slight tendency, but for the price, employment, and labor force variables there is more of a tendency. For the unemployment rate, for example, MAE increases from .0017 for the one-quarter-ahead forecast to .0040 for the five-quarter-ahead forecast. For the errors in terms of changes, on the other hand, there is very little evidence of error compounding. The errors in terms of changes are also in general smaller than the corresponding errors in terms of levels. The one major exception is the inventory investment variable. Notice also that the sum of the errors made in predicting the components of GNP_t is always greater than the actual error in predicting GNP_t, which implies that there is a good deal of error cancellation among the various components.

In order to examine the simulation results in more detail, the quarter-by-quarter results are presented in Table 11–6 for eleven variables. The variables include GNP_t, total consumption expenditures $CD_t + CN_t + CS_t$, plant and equipment investment IP_t, housing investment IH_t, inventory investment $V_t - V_{t-1}$, imports IMP_t, the private output deflator PD_t, real gross national product $GNPR_t$, private nonfarm employment M_t, the total labor force $LF_{1t} + LF_{2t}$, and the unemployment rate UR_t. In the table, for each quarter, the first line gives the actual change in each of the variables for that quarter, and the next five lines give respectively the one-, two-, three-, four-, and five-quarter-ahead forecast of the change in each of the variables for that quarter.[3] For 694, for example, the actual change in money GNP was 9.40 billion dollars, the one-quarter-ahead forecast (starting from 693) was 6.74, the two-quarter-ahead forecast (starting from 692) was 9.73, the three-quarter-ahead forecast (starting from 691) was 9.06, the four-quarter-ahead forecast (starting from 684) was 9.61, and finally the five-quarter-ahead forecast (starting from 683) was 9.40. For 602 and 653, the initial quarters after the strike periods, only one-quarter-ahead forecasts could, of course, be computed; for 603 and 654 only one- and two-quarter-ahead forecasts could be computed; and so on.

The results in Table 11–6 will not be discussed in detail, since they are rather self-explanatory, but a few of their more notable features will be mentioned. Looking at the money GNP forecasts first, there were four quarters (of the 36 quarters considered) in which errors larger than 5 billion dollars occurred: 611, 612, 654, and 671. The one- and two-quarter-ahead forecasts for 611 were about 5 billion dollars too high, and the forecasts for 612 were between about 4 and 9 billion dollars too low. In general, the slow growth of GNP during the 602–611 period was caught fairly well,

[3] Using the notation in footnote 1, the j-quarter-ahead forecast ($j = 2, 3, 4, 5$) of variable y_i for quarter t presented in Table 11–6 is $y_{pit}^{(j)} - y_{pit-1}^{(j-1)}$. The one-quarter-ahead forecast is $y_{pit}^{(j)} - y_{it-1}$.

Table 11–6. Actual and Forecasted Changes for Selected Variables of the Model. (Forecasts are within-sample forecasts and are based on actual values of the exogenous variables. Forecasts for UR_t are in terms of levels.)

Quarter	Length of Forecast	GNP_t	$CD_t+CN_t+CS_t$	IP_t	IH_t	V_t-V_{t-1}	IMP_t	PD_t	$GNPR_t$	M_t	$LF_{1t}+LF_{2t}$	UR_t
602		1.70	5.20	1.20	−1.60	−6.00	.20	.43	−.50	160	925	.0524
	1	5.15	5.09	1.68	−1.71	−2.61	.40	.37	3.14	239	201	.0485
603		−.50	−.40	−.60	−1.10	−.80	−.60	.17	−2.40	−240	198	.0556
	1	5.14	3.40	.55	−.86	.75	.40	.36	2.24	−101	177	.0532
	2	3.91	3.76	.40	−.71	−.93	.31	.37	1.00	131	365	.0471
604		−.90	1.80	.0	−.40	−5.50	−1.40	.50	−3.60	−278	352	.0626
	1	1.92	3.07	−.16	−.56	−2.08	.15	.33	−.15	−265	94	.0593
	2	3.26	2.29	−.33	−.03	−.33	.25	.35	1.06	−46	160	.0561
	3	2.17	2.11	−.45	.05	−1.28	.17	.36	−.05	−99	277	.0504
611		.30	.70	−2.40	.10	−1.10	.10	.24	−1.10	−119	285	.0678
	1	5.47	2.59	−1.05	−.23	1.58	.43	.30	3.65	−197	26	.0651
	2	5.42	2.37	−.94	.48	.93	.42	.30	3.55	−194	118	.0629
	3	2.99	2.23	−1.27	.50	−1.24	.23	.32	1.10	−135	138	.0596
	4	1.83	2.06	−1.38	.41	−2.12	.14	.34	−.06	−208	225	.0549
612		11.30	3.90	.0	.40	5.60	.20	.03	10.20	−121	−6	.0699
	1	6.64	2.61	−.03	.74	2.34	.52	.24	4.79	−114	−5	.0726
	2	7.08	3.58	−.32	1.08	1.69	.55	.26	5.15	−95	−6	.0696
	3	5.07	3.16	−.38	1.20	−.12	.40	.27	3.17	−73	44	.0678
	4	2.93	2.47	−.63	.58	−.86	.23	.29	1.00	−167	28	.0654
	5	2.23	2.26	−.70	.55	−1.30	.17	.30	.29	−236	94	.0616

613		9.30	4.40	1.50	.80	1.70	1.40	−.02	8.70	277	−85	.0676
	1	9.27	4.62	1.42	.61	1.13	.72	.23	7.57	182	147	.0682
	2	10.73	5.10	1.43	.83	1.90	.84	.22	9.02	93	180	.0710
	3	10.00	4.69	1.17	1.10	1.53	.78	.24	8.22	143	226	.0683
	4	7.62	4.02	1.07	.42	.41	.59	.24	5.91	57	235	.0674
	5	6.07	3.53	.89	.28	−.45	.47	.26	4.32	−53	216	.0657
614		13.50	6.40	1.10	.90	1.70	.40	.51	10.20	588	72	.0618
	1	12.36	5.68	1.85	1.19	.81	.96	.22	10.41	329	297	.0646
	2	12.88	6.03	1.90	1.03	1.01	1.00	.22	10.89	270	222	.0660
	3	14.37	6.01	1.94	.72	2.92	1.12	.20	12.36	341	244	.0678
	4	12.44	5.77	1.67	.48	1.59	.97	.22	10.40	321	279	.0657
	5	11.09	5.23	1.62	.42	.79	.87	.23	9.10	231	280	.0656
621		10.10	5.20	.90	.60	1.20	.60	.34	7.80	447	176	.0563
	1	10.90	5.60	1.47	.48	1.29	.85	.21	9.16	422	446	.0565
	2	11.47	6.28	1.25	.86	1.07	.90	.21	9.74	476	383	.0590
	3	12.10	6.26	1.31	.95	1.62	.94	.21	10.32	416	324	.0610
	4	12.53	6.43	1.30	.62	2.26	.98	.19	10.80	433	323	.0623
	5	11.45	6.04	1.13	.60	1.67	.89	.21	9.65	400	349	.0608
622		9.40	3.40	1.80	1.00	−.60	.60	.14	8.20	397	114	.0550
	1	11.90	6.76	1.24	.46	−.03	.93	.21	10.25	398	355	.0564
	2	11.81	6.86	1.07	.60	−.10	.92	.21	10.17	590	284	.0555
	3	12.30	6.75	.92	.23	1.05	.96	.21	10.65	481	211	.0585
	4	12.66	6.91	.96	.46	1.02	.99	.21	10.98	496	180	.0605
	5	13.20	7.02	.96	.45	1.49	1.03	.20	11.56	496	173	.0614
623		7.20	5.50	1.80	.60	−.90	.10	.21	5.70	23	305	.0555
	1	6.01	6.57	1.20	−.11	−1.27	.47	.21	4.58	271	381	.0553
	2	8.19	5.97	1.56	.32	.89	.64	.22	6.62	518	401	.0555
	3	8.20	5.98	1.45	.34	.98	.64	.22	6.61	434	331	.0552
	4	7.82	6.03	1.30	−.00	1.00	.61	.23	6.25	432	294	.0581
	5	8.08	6.11	1.33	.05	1.12	.63	.23	6.48	465	276	.0599

Table 11–6 (cont.)

Quarter	Length of Forecast	GNP_t	$CD_t + CN_t + CS_t$	IP_t	IH_t	$V_t - V_{t-1}$	IMP_t	PD_t	$GNPR_t$	M_t	$LF_{1t} + LF_{2t}$	UR_t
624		7.60	5.80	−.40	−.40	1.20	.30	.30	4.90	−184	−4	.0552
	1	7.62	5.88	.53	−.32	.52	.59	.23	5.23	193	335	.0575
	2	9.00	5.14	.78	.28	1.70	.70	.23	6.55	386	397	.0559
	3	7.33	4.70	.83	.47	.09	.57	.24	4.89	311	342	.0565
	4	7.13	4.70	.74	.39	.05	.56	.25	4.68	285	306	.0564
	5	7.10	4.66	.66	.36	.18	.55	.25	4.65	317	286	.0591
631		5.40	5.20	−.70	.50	−1.70	−.10	.30	2.90	261	377	.0579
	1	8.16	5.43	.55	.81	−.09	.64	.26	5.70	116	385	.0577
	2	7.93	5.04	.24	.36	.70	.62	.26	5.48	197	361	.0585
	3	7.51	5.03	.33	.70	−.16	.59	.26	5.10	211	364	.0566
	4	6.15	4.44	.35	.65	−1.01	.48	.27	3.73	125	311	.0575
	5	6.06	4.41	.29	.67	−1.04	.47	.28	3.61	119	290	.0575
632		6.80	3.80	1.50	.70	.10	.70	.31	4.80	302	458	.0570
	1	9.27	5.73	1.71	.32	.83	.72	.27	7.34	273	463	.0597
	2	7.98	5.92	1.30	.24	−.16	.62	.28	6.09	199	375	.0596
	3	7.73	5.94	1.08	.47	−.46	.60	.28	5.86	224	341	.0595
	4	7.40	5.64	1.14	.28	−.38	.58	.27	5.56	164	323	.0578
	5	6.39	5.21	1.15	.25	−1.02	.50	.29	4.53	103	282	.0588
633		10.50	6.30	1.50	.30	1.20	.70	.18	8.70	412	249	.0551
	1	9.46	5.89	1.83	.62	−.24	.74	.28	7.25	343	421	.0583
	2	9.54	5.30	1.82	.36	.70	.74	.29	7.29	464	430	.0591
	3	8.59	5.22	1.53	.03	.39	.67	.29	6.36	344	392	.0600
	4	8.74	5.16	1.40	.21	.55	.68	.29	6.51	311	351	.0594
	5	8.42	5.02	1.44	.17	.35	.66	.29	6.22	242	331	.0580

634		11.10	3.20	1.80	.90	2.10	.20	.35	7.40	119	322	.0558
	1	11.52	6.25	1.91	.79	.16	.90	.29	8.05	443	489	.0549
	2	11.12	5.69	1.76	.22	1.23	.87	.29	7.70	478	435	.0570
	3	10.06	5.58	1.68	.49	−.00	.78	.30	6.65	394	418	.0577
	4	9.51	5.52	1.49	.53	−.38	.74	.30	6.10	375	417	.0590
	5	9.42	5.50	1.39	.53	−.36	.74	.30	6.02	325	378	.0582
641		11.90	10.20	1.50	−.30	−3.30	.50	.24	9.00	444	288	.0547
	1	9.89	8.81	.62	−.01	−3.16	.77	.29	6.85	326	322	.0579
	2	12.08	7.28	.73	.20	.41	.94	.30	8.89	597	389	.0555
	3	11.74	7.30	.63	.06	.27	.92	.29	8.60	464	330	.0579
	4	11.58	7.09	.61	.47	−.09	.90	.30	8.40	439	328	.0585
	5	11.23	7.00	.48	.49	−.25	.88	.31	8.04	453	337	.0599
642		10.30	5.90	1.80	−.50	1.30	.70	.35	7.50	458	663	.0524
	1	14.42	7.31	2.20	.02	3.61	1.12	.31	11.55	604	426	.0536
	2	12.93	7.22	2.34	−.59	2.67	1.01	.30	10.20	528	431	.0568
	3	11.27	7.14	2.22	−.58	1.07	.88	.31	8.62	507	413	.0545
	4	11.96	7.14	2.20	−.22	1.47	.93	.30	9.31	484	388	.0566
	5	11.57	7.01	2.17	−.19	1.18	.90	.31	8.88	481	389	.0571
643		10.90	9.00	2.30	−.10	−1.30	.50	.40	7.20	303	−109	.0501
	1	10.60	8.00	1.78	−.05	.10	.83	.31	7.35	443	313	.0529
	2	9.53	7.31	1.66	−.53	.14	.74	.32	6.29	643	465	.0521
	3	10.12	7.34	1.86	−.34	.36	.79	.31	6.91	491	429	.0557
	4	9.70	6.79	1.83	−.40	.54	.76	.32	6.48	408	394	.0537
	5	9.96	6.87	1.80	−.35	.72	.78	.31	6.77	420	382	.0556
653		15.40	8.40	2.90	.30	.20	.30	.19	12.10	597	264	.0437
	1	11.17	6.89	.99	.15	.12	.87	.41	7.11	477	300	.0470
654		18.90	11.10	3.80	.20	.60	1.50	.34	14.10	731	358	.0411
	1	13.66	8.61	1.48	−.32	.25	1.07	.46	8.71	614	465	.0430
	2	13.16	8.23	1.96	−.32	−.38	1.03	.44	8.34	649	474	.0454

Table 11–6 (cont.)

Quarter	Length of Forecast	GNP_t	$CD_t + CN_t + CS_t$	IP_t	IH_t	$V_t - V_{t-1}$	IMP_t	PD_t	$GNPR_t$	M_t	$LF_{1t} + LF_{2t}$	UR_t
661		19.50	10.30	2.60	.0	1.60	1.50	.78	12.50	584	345	.0386
	1	18.86	8.66	2.55	.32	2.40	1.47	.54	13.21	827	559	.0380
	2	17.27	8.81	3.07	−.34	.67	1.35	.52	11.90	841	535	.0396
	3	17.41	8.69	3.43	−.42	.67	1.36	.49	12.17	659	490	.0426
662		13.80	4.10	1.50	−1.50	4.90	1.10	1.07	5.90	603	507	.0383
	1	14.94	7.60	1.61	−.42	1.52	1.17	.63	9.33	690	560	.0351
	2	13.66	8.40	1.53	−.51	−.61	1.07	.62	8.19	934	596	.0334
	3	15.50	8.44	2.08	−.16	.46	1.21	.59	10.08	741	532	.0359
	4	16.09	8.41	2.36	−.01	.69	1.25	.55	10.82	688	513	.0388
663		12.60	9.30	2.70	−1.20	−4.30	2.20	.88	5.20	656	576	.0377
	1	9.73	7.22	1.93	−.97	−5.80	.76	.71	3.59	432	479	.0364
	2	14.11	7.53	2.20	−1.03	−1.68	1.10	.73	7.39	808	549	.0322
	3	14.90	7.61	2.25	−1.40	−.59	1.16	.73	8.13	672	493	.0313
	4	16.90	8.08	2.67	−.64	−.10	1.32	.68	10.20	681	478	.0336
	5	17.31	8.11	2.86	−.61	.10	1.35	.63	10.86	677	469	.0362
664		14.80	3.40	1.20	−2.70	8.00	.60	.88	7.90	290	688	.0369
	1	10.00	5.74	1.36	−1.51	−.31	.78	.82	3.96	399	541	.0344
	2	10.29	6.57	1.56	−1.08	−1.65	.80	.81	4.30	514	558	.0332
	3	9.98	6.04	1.53	−1.40	−1.11	.78	.85	3.75	473	539	.0298
	4	10.48	6.39	1.57	−1.30	−1.05	.82	.85	4.20	430	505	.0290
	5	11.75	6.73	1.85	−1.20	−.41	.92	.80	5.66	486	503	.0309

671		3.50	6.60	−.90	−.60	−10.90	.50	.60	−1.60	258	358	.0376
	1	8.11	7.66	.19	.51	−9.72	.63	.93	.69	204	337	.0355
	2	12.45	6.34	.32	.26	−3.60	.97	.92	4.61	477	470	.0323
	3	15.06	6.96	.61	.13	−1.56	1.18	.91	6.98	402	458	.0320
	4	13.64	6.53	.51	−.37	−2.06	1.06	.97	5.35	345	438	.0293
	5	14.11	6.71	.54	−.37	−1.78	1.10	.98	5.75	325	414	.0284
672		9.30	8.60	−.30	1.60	−5.60	−.30	.57	4.00	32	171	.0386
	1	8.91	5.66	−.19	2.69	−3.15	.70	1.00	1.41	64	233	.0371
	2	9.29	6.49	−.41	2.55	−2.91	.73	1.02	1.59	185	319	.0360
	3	10.03	6.73	−.47	2.04	−1.80	.78	1.01	2.30	215	356	.0329
	4	11.19	7.36	−.31	1.53	−.81	.87	1.01	3.32	271	374	.0327
	5	10.38	6.96	−.36	1.40	−1.11	.81	1.09	2.11	223	360	.0305
673		16.90	6.00	.50	3.40	4.40	.60	1.12	7.50	186	752	.0386
	1	16.19	8.32	1.49	2.91	1.44	1.26	1.07	7.14	288	469	.0367
	2	12.98	9.21	1.24	2.67	−2.53	1.01	1.05	4.46	237	447	.0362
	3	11.97	8.82	1.01	2.31	−2.64	.93	1.08	3.40	172	435	.0360
	4	13.02	8.68	1.01	1.91	−.96	1.02	1.08	4.35	168	451	.0332
	5	14.11	9.17	1.13	1.88	−.37	1.10	1.08	5.23	243	474	.0327
674		15.70	6.90	1.50	2.40	1.70	2.10	1.05	5.50	453	571	.0392
	1	14.30	10.35	1.18	1.99	−3.60	1.12	1.12	3.94	277	386	.0380
	2	17.85	9.80	1.08	2.45	.51	1.39	1.12	6.95	398	479	.0353
	3	18.72	10.01	1.10	2.16	1.50	1.46	1.09	7.92	347	456	.0354
	4	16.90	9.76	.87	1.69	.50	1.32	1.12	6.17	276	431	.0358
	5	17.42	9.87	.86	1.65	1.00	1.36	1.12	6.61	273	441	.0331
681		19.20	18.10	4.10	−.30	−7.90	3.10	.98	9.80	434	106	.0369
	1	19.17	12.62	3.04	.70	−3.79	1.50	1.14	8.91	435	363	.0370
	2	24.20	11.24	3.43	1.48	2.04	1.89	1.14	13.16	564	418	.0356
	3	23.15	10.74	3.14	1.63	1.55	1.81	1.16	12.17	543	467	.0331
	4	23.06	11.06	3.12	1.12	1.66	1.80	1.11	12.38	519	453	.0335
	5	22.08	10.72	2.97	1.01	1.20	1.72	1.13	11.38	461	431	.0343

Table 11–6 (cont.)

Quarter	Length of Forecast	GNP_t	$CD_t + CN_t + CS_t$	IP_t	IH_t	$V_t - V_{t-1}$	IMP_t	PD_t	$GNPR_t$	M_t	$LF_{1t} + LF_{2t}$	UR_t
682		23.40	9.60	−2.70	1.70	8.30	1.40	1.15	12.50	533	508	.0360
	1	26.04	8.60	.92	1.22	9.43	2.03	1.18	14.54	682	437	.0333
	2	21.12	10.87	.94	.27	2.59	1.65	1.16	10.50	672	399	.0342
	3	20.84	11.02	.97	.33	2.03	1.63	1.18	10.14	633	414	.0334
	4	19.66	10.42	.75	.19	1.74	1.53	1.19	9.04	569	441	.0314
	5	19.94	10.57	.75	.10	1.97	1.56	1.13	9.66	549	430	.0320
683		17.70	14.60	1.70	−.30	−2.70	2.40	1.03	7.00	253	146	.0356
	1	18.60	10.51	3.31	.09	−.65	1.45	1.21	6.74	487	391	.0351
	2	17.32	11.42	2.15	.34	−2.03	1.35	1.23	5.58	644	433	.0320
	3	20.14	11.85	2.55	.27	.24	1.57	1.20	8.14	521	362	.0337
	4	20.16	11.45	2.59	−.12	1.02	1.57	1.22	7.99	513	378	.0332
	5	19.30	11.02	2.43	−.13	.68	1.51	1.24	7.18	458	398	.0317
684		16.10	5.80	3.40	2.00	3.30	1.30†	1.20	5.70	399	226	.0340
	1	18.83	8.50	1.69	.67	4.35	1.47	1.24	7.74	421	433	.0350
	2	14.89	9.36	.96	−.04	.67	1.16	1.23	4.55	521	394	.0339
	3	14.77	9.34	.21	−.02	1.29	1.15	1.24	4.34	366	375	.0319
	4	16.00	10.40	.45	.04	1.26	1.25	1.21	5.57	395	343	.0334
	5	15.80	10.32	.46	.01	1.14	1.23	1.24	5.20	411	361	.0331
691		16.20	11.30	3.80	1.40	−3.90	1.40†	1.40	4.60	733	959	.0336
	1	19.67	11.54	5.55	.17	−2.85	1.53	1.29	8.06	444	486	.0331
	2	18.23	10.20	6.04	.38	−1.57	1.42	1.31	6.78	517	433	.0334
	3	19.20	10.69	5.77	.31	−.67	1.50	1.28	7.73	417	376	.0327
	4	18.67	10.84	5.23	.46	−1.00	1.46	1.30	7.19	351	376	.0314
	5	19.99	11.43	5.42	.48	−.38	1.56	1.26	8.48	396	355	.0326

692		16.10	10.80	2.50	−.60	.30	1.40†	1.55	3.60	439	280	.0349
	1	18.86	10.37	1.58	−.17	2.85	1.47	1.34	6.95	444	342	.0322
	2	15.80	10.01	.92	−.16	2.36	1.23	1.36	4.35	479	476	.0319
	3	14.33	9.78	1.23	.28	.26	1.12	1.37	3.09	324	406	.0329
	4	15.49	10.46	1.07	.63	.63	1.21	1.34	4.21	306	379	.0323
	5	15.13	10.42	.70	.67	.62	1.18	1.35	3.82	265	382	.0313
693		18.00	7.00	3.30	−1.30	3.80	1.40†	1.41	3.90	334	688	.0363
	1	20.36	10.88	3.14	−1.02	2.56	1.59	1.36	6.05	288	331	.0369
	2	17.50	10.82	3.30	−1.22	.77	1.36	1.38	3.65	486	290	.0335
	3	17.14	10.95	2.95	−.71	.09	1.34	1.40	3.25	266	316	.0345
	4	17.30	10.61	3.24	−.10	−.29	1.35	1.41	3.33	220	283	.0357
	5	18.08	11.07	3.13	−.05	.14	1.41	1.37	4.16	212	264	.0351
694		9.40	9.60	1.40	.10	−3.00	.70	1.36	−.80	210	417	.0359
	1	6.74	8.74	−.55	−.72	−2.11	.53	1.32	−2.67	8	206	.0395
	2	9.73	7.88	−.26	−1.01	1.79	.76	1.35	−.49	233	313	.0377
	3	9.06	7.90	−.07	−1.20	1.05	.71	1.36	−1.11	101	264	.0356
	4	9.61	8.03	−.26	−.56	1.05	.75	1.39	−.81	104	314	.0369
	5	9.40	7.87	−.08	−.48	.73	.73	1.39	−1.01	96	296	.0380

† Adjusted value rather than the actual value.

although the upturn in 612 was missed. This latter error was due primarily to errors made in forecasting inventory investment. No large errors were made in forecasting GNP_t for the 613–643 period—even the moderate sluggishness in the 623–632 period was picked up—and the next error of larger than 5 billion dollars did not occur until 654. In 654 the change in GNP was underpredicted by about 5 billion dollars, on top of an underprediction of about 4 billion dollars in 653. In both of these quarters, consumption and plant and equipment investment were underpredicted. The next quarter in which large errors were made was 671, where errors between about 4.5 and 11.5 billion dollars were made. The small increase in GNP in 671 was not captured by the model, due primarily to a failure to forecast accurately the 10.90 billion dollar decrease in inventory investment in 671. The remaining 672–694 period was forecast fairly well, including the slowdown in 694. In particular, no significant slowdown in the last half of 1968 was forecast by the model, a slowdown many economists were expecting after the tax increase was passed in June 1968.

With respect to the forecast of GNP, then, there appear to be only two or three quarters in which the model gave misleading results. The model missed the upturn in 612, it underpredicted the increase in GNP in 654 by about 5 billion dollars, and it missed the slowdown in 671. The largest errors were made in 671. Inventory investment increased from 11.9 billion dollars in 663 to 19.9 billion dollars in 664 and then decreased to 9.0 billion dollars in 671. The model failed to forecast the 8.0 billion dollar increase in inventory investment in 664, but offsetting errors in the model (namely, in consumption) caused the overall GNP forecasts to be moderately good. The model then failed to forecast (aside from the one-quarter-ahead forecast) the 10.9 billion dollar decrease in inventory investment in 671. This time there were no offsetting errors, and thus large errors in forecasting the change in GNP were made.

With respect to the forecasts of the change in the price deflator, the largest errors occurred in 662, where the model underpredicted the rate of inflation, and in 672, where the model overpredicted the rate of inflation. The inflation in the last half of the 1960s was caught quite well, aside from a slight underprediction in 691 and 692. With respect to the unemployment rate, the forecasts in Table 11–6 are in terms of levels rather than changes, since the level of the unemployment rate is the most widely followed. There is a tendency for the errors in forecasting the unemployment rate to compound as the forecast horizon lengthens. This is definitely true for the 602–611 period, and also for the 664–674 period. In both periods the unemployment rate was more and more underpredicted as the forecast horizon lengthened. For the 602–611 period this was due primarily to the failure of the model to forecast the large increase in the labor force in 602. In general, however, the high unemployment rates in the early 1960s and the low rates in the late 1960s were caught moderately well.

The forecasts in Table 11–6 are not, of course, *ex ante* forecasts. They are within-sample forecasts and are based on the use of actual values for the exogenous variables. The results in Table 11–6 are thus better than are likely to be achieved in practice. In Chapter 12 outside-sample forecasts will be generated and compared with the within-sample forecasts in Table 11–6 to see how much accuracy is lost by having to make outside-sample forecasts. The sensitivity of the results to likely errors made in forecasting the exogenous variables will then be examined in Chapter 13. The forecasts in Chapter 13 are close to being forecasts that could have been generated *ex ante.*

What has been shown in this chapter, however, is that *ex post* the model is capable of tracking the economy quite well. This is contrary to the conclusion reached by Evans, Haitovsky, and Treyz [14] for the Wharton and OBE models. As mentioned in Chapter 1, Evans et al. found that even when within-sample forecasts were made and actual values of the exogenous variables were used, the forecasts generated by the Wharton and OBE models were not very good. The results achieved by Evans, et al. will be examined in more detail in Chapter 14, but it does appear from the results in this chapter that their pessimistic conclusion about econometric models may be related to the particular models they considered.

Results from the Monthly Housing Starts Equations

So far no explicit mention has been made of the accuracy of the monthly housing starts equations, but it is implicit in the results presented above for housing investment. Since the monthly housing starts forecasts are used to construct forecasts of the quarterly (seasonally adjusted) housing starts variable, HSQ_t, it is appropriate to examine the forecasts of HSQ_t. In Table 11–7 the mean absolute errors in terms of levels and changes are

Table 11–7. Errors in Forecasting HSQ_t. (Forecasts of HSQ_t are based on the forecasts from the monthly housing starts sector. The errors are computed for the same prediction period and are in thousand of units at annual rates.)

Error Measure	Length of Forecast One Quarter Ahead	Two Quarters Ahead	Three Quarters Ahead	Four Quarters Ahead	Five Quarters Ahead	No. of Observations
MAE	56.4	66.2	68.2	68.4	68.4	28
MAEΔ	56.4	58.9	56.0	58.2	59.0	28

Table 11–8. Actual and Forecasted Levels of HSQ_t. (Forecasts are within-sample forecasts and are based on actual values of the exogenous variables. Figures are in thousands of units at annual rates.)

		Length of Forecast				
Quarter	Actual Value	One Quarter Ahead	Two Quarters Ahead	Three Quarters Ahead	Four Quarters Ahead	Five Quarters Ahead
602	1224	1212				
603	1203	1224	1243			
604	1134	1177	1265	1270		
611	1211	1208	1285	1308	1309	
612	1214	1323	1343	1353	1354	1354
613	1334	1314	1329	1334	1334	1330
614	1310	1412	1377	1376	1377	1373
621	1356	1387	1426	1418	1411	1410
622	1433	1413	1409	1412	1412	1407
623	1401	1375	1398	1396	1393	1395
624	1484	1413	1458	1465	1464	1458
631	1447	1514	1485	1498	1500	1499
632	1594	1494	1474	1472	1473	1473
633	1557	1530	1499	1492	1494	1494
634	1628	1597	1546	1542	1539	1543
641	1603	1514	1548	1536	1542	1540
642	1473	1480	1456	1462	1463	1468
643	1402	1490	1450	1447	1448	1451
644	1491	1408	1482	1470	1473	1473
651	1396	1453	1443	1459	1457	1463
652	1475	1391	1399	1400	1398	1399
653	1384	1389	1344	1345	1348	1341
654	1463	1353	1344	1335	1333	1337
661	1349	1397	1308	1305	1309	1306
662	1267	1311	1306	1295	1295	1300
663	1018	1115	1168	1166	1168	1168
664	883	998	1044	1057	1055	1063
671	1038	1095	1100	1108	1107	1105
672	1206	1266	1307	1305	1302	1298
673	1316	1331	1369	1378	1374	1369
674	1420	1456	1472	1480	1478	1473
681	1436	1410	1472	1476	1473	1468
682	1434	1443	1402	1411	1411	1407
683	1448	1414	1407	1397	1397	1396
684	1548	1452	1396	1394	1394	1390
691	1604	1478	1440	1426	1426	1429
692	1507	1513	1470	1467	1467	1467
693	1341	1361	1366	1359	1361	1365
694	1290	1381	1338	1339	1343	1348

presented for HSQ_t for the one-through five-quarter-ahead forecasts. The errors are in thousands of units *at annual rates* and have been computed for the 28 quarters for which five-quarter-ahead forecasts were made. The errors range from 56.0 to 68.4 thousand units and in general show little evidence of error compounding

In Table 11–8 the quarter-by-quarter forecasts of HSQ_t are presented for the 602–694 period. Since no strike observations were omitted from the sample period for the monthly housing starts equations, the results for the entire 602–694 period are presented in Table 11–8. The error measures presented in Table 11–7 thus correspond to a subset of the forecasts presented in Table 11–8. The results in Table 11–8 appear to be fairly good. The crunch in late 1966 and early 1967 was overpredicted, but not too badly. The slowdown in the last half of 1969 was also captured moderately well.

The Reduced Form Equation for GNP

The reduced form equation in (11.4) for GNP_t for the final version of the model is:

$$\begin{aligned} GNP_t = & -45.17 - .004GNP_{t-1} + 1.839CD_{t-1} + 1.402CN_{t-1} + 1.068CS_{t-1} \\ & - .802CD_{t-2} - .538CN_{t-2} + .090CS_{t-2} + .849IP_{t-1} + .553IH_{t-1} \\ & + .974(V_{t-1} - V_{t-2}) - .440V_{t-1} + .348V_{t-2} - 1.232IMP_{t-1} \\ & + .846PE2_t - .583PE2_{t-1} + .0298HSQ_t + .0150HSQ_{t-1} \\ & - .0036HSQ_{t-2} - .0041HSQ_{t-3} + .122MOOD_{t-1} \\ & + .231MOOD_{t-2} - .079MOOD_{t-3} + 1.232(G_t + EX_t). \end{aligned} \tag{11.9}$$

Some of the lagged endogenous variables in equation (11.9) are serving both in their capacity as predetermined variables—i.e., as those in X in (11.4)—and as lagged values of the endogenous variables—i.e., as those in Y_{-1} in (11.4). The short-run government multiplier for the model is 1.232, as can be seen from the coefficient of $G_t + EX_t$ in equation (11.9). According to this equation, an increase in exports or government spending of, say, one billion dollars will lead to a 1.232 billion dollar increase in GNP in the same quarter.

Care must be used in the interpretation of the short-run multiplier because of the expectational variables in the model. If, for example, government expenditure policy affects consumer sentiment or plant and equipment investment expectations, this will have an effect on GNP for quarters beyond $t + 1$ or $t + 2$, and these kinds of effects are not incorporated into the 1.232 multiplier.