12 The Stability of the Estimated Relationships and the Outside-Sample Forecasts

12.1 Introduction

In this chapter the stability of the estimated relationships of the model will be examined, and outside-sample forecasts will be generated. "Stability" is meant to refer to how much or little the coefficient estimates in an equation change as the sample period is lengthened. The less the coefficient estimates in an equation change as the sample is lengthened, the more stable the equation is considered to be. In the limit, for a perfectly stable model, the outside-sample forecasting results would be the same as the within-sample results, since the coefficient estimates would be the same in both cases. Otherwise, one would expect the outside-sample results to be somewhat poorer than the within-sample results.

Unless the estimated relationships in a model are reasonably stable over time, the model will be of limited use as a forecasting tool. The basic assumption of any forecasting model is that relationships that have been estimated for the past will continue to hold for the future. The advantage of a small scale model such as the present one is that the validity of this assumption can be tested by estimating each of the equations of the model over different sample periods and comparing the results. This will be done in Section 12.2. Having done this, the different sets of estimates can by used to generate forecasts beyond the sample period, and these forecasts can be compared with the within-sample forecasts of Chapter 11. This is the purpose of Section 12.3.

12.2 Stability Results

The Procedure

The validity of the stability assumption was examined in the following manner. Each of the twelve quarterly behavioral equations was estimated eighteen times, with the sample period first ending in 653, then in 654, and so on through 694. For each equation the beginning of the sample period was the same as before: 602 for the nondurable consumption and housing investment equations and 561 for the others. Also as before, the strike observations were omitted from all of the sample periods. The two monthly housing starts equations were also estimated eighteen times, with the first sample period ending in September 1965, and the successive sample periods being increased by three months each time. The coefficient estimates from these equations can then be examined for their stability over time, and from this examination a judgement can be made as to the probable usefulness of each of the equations for forecasting purposes.

In the rest of this section the results of estimating the equations over the different sample periods will be presented and discussed. All of the coefficient estimates are presented, since these are the estimates that have been used to generate the outside-sample forecasts below. It should be stressed that the following discussion of the stability of the estimates is quite informal and subjective. A much better idea of how "stable" the model is can be achieved by comparing the within-sample and outside-sample forecasting results, and this will be done in the next section. It should also be stressed that the different coefficient estimates achieved below by estimating the equations over the different sample periods are not statistically independent of one another, since the sample periods all overlap. The purpose of the following analysis is not to test in any rigorous way the hypothesis that coefficients of an equation are the same for different sample periods.

Consumption of Durables

In Table 12–1 the results of estimating equation (3.1) for the eighteen different sample periods are presented. The eighteenth equation estimate is the one that has already been presented in Chapter 3. For the first equation estimate in the table, the sample period ended in 653, and for the successive estimates after that, the end of the sample period was increased one quarter at a time. For this particular equation, the sample period began in 561, and the observations for 593, 594, 601, 644, 651, and 652 were omitted because of strikes.

From the results in Table 12–1, the stability of the durables equation appears to be fairly good. The only large change that occurred was in the estimate of the serial correlation coefficient, which was as high as .847 for the period ending in 661 and as low as .579 for the period ending in 681. The coefficient estimate of the GNP variable is remarkably stable for the different periods.

Consumption of Nondurables

In Table 12–2 the results of estimating equation (3.7) for the eighteen sample periods are presented. For this equation the sample period began in 602,

Table 12–1. Coefficient Estimates of Equation (3.1) for Eighteen Sample Periods. (Dependent variable is CD_t.)

End of Sample Period	No. of Obser-vations	Coefficient Estimates for Con-stant	$\widehat{GNP}_t$	$MOOD_{t-1}$	$MOOD_{t-2}$	$\hat{r}$	SE	$R\Delta^2$
653	33	−30.51	.106	.106	.128	.839	.736	.744
		(5.22)	(10.71)	(2.20)	(2.73)	(8.87)		
654	34	−30.92	.107	.105	.128	.843	.724	.756
		(5.63)	(12.02)	(2.23)	(2.77)	(9.15)		
661	35	−31.26	.108	.104	.127	.847	.711	.765
		(5.91)	(13.30)	(2.27)	(2.82)	(9.43)		
662	36	−27.96	.093	.149	.134	.748	.928	.648
		(4.63)	(13.98)	(2.51)	(2.29)	(6.77)		
663	37	−26.71	.098	.119	.120	.684	.971	.625
		(4.56)	(19.01)	(1.97)	(1.98)	(5.71)		
664	38	−26.50	.099	.116	.118	.688	.957	.625
		(4.64)	(21.46)	(2.00)	(1.99)	(5.84)		
671	39	−27.65	.097	.124	.134	.672	.964	.637
		(4.96)	(23.18)	(2.14)	(2.30)	(5.67)		
672	40	−27.73	.100	.149	.094	.657	1.009	.624
		(4.83)	(25.14)	(2.51)	(1.63)	(5.51)		
673	41	−25.87	.097	.145	.094	.601	1.055	.581
		(4.66)	(28.42)	(2.33)	(1.55)	(4.82)		
674	42	−25.55	.097	.145	.093	.607	1.044	.585
		(4.64)	(29.27)	(2.35)	(1.55)	(4.95)		
681	43	−25.57	.099	.113	.112	.579	1.090	.587
		(4.59)	(32.42)	(1.81)	(1.81)	(4.66)		
682	44	−25.53	.100	1.17	.103	.595	1.080	.592
		(4.55)	(33.80)	(1.92)	(1.74)	(4.92)		
683	45	−25.69	.103	.089	.116	.655	1.134	.575
		(4.10)	(30.55)	(1.41)	(1.87)	(5.81)		
684	46	−25.70	.103	.089	.117	.653	1.121	.575
		(4.15)	(32.53)	(1.42)	(1.92)	(5.85)		
691	47	−25.84	.103	.085	.116	.676	1.116	.574
		(4.10)	(32.60)	(1.37)	(1.92)	(6.28)		
692	48	−26.39	.104	.091	.111	.697	1.110	.574
		(4.14)	(32.51)	(1.49)	(1.85)	(6.73)		
693	49	−25.93	.102	.115	.093	.648	1.136	.555
		(4.17)	(37.44)	(1.90)	(1.55)	(5.96)		
694	50	−25.43	.103	.110	.092	.648	1.125	.554
		(4.22)	(39.78)	(1.88)	(1.54)	(6.01)		

Table 12–2. Coefficient Estimates of Equation (3.7) for Eighteen Sample Periods. (Dependent variable is CN_t.)

End of Sample Period	No. of Obser-vations	Coefficient Estimates for $\widehat{GNP}_t$	CN_{t-1}	$MOOD_{t-2}$	$\hat{r}$	SE	$R\Delta^2$
653	19	.048 (2.73)	.810 (8.38)	.059 (0.87)	−.548 (2.86)	1.069	.536
654	20	.051 (2.87)	.808 (8.26)	.047 (0.69)	−.575 (3.15)	1.098	.603
661	21	.055 (2.87)	.793 (7.39)	.044 (0.59)	−.467 (2.42)	1.135	.607
662	22	.054 (2.91)	.806 (8.04)	.034 (0.51)	−.469 (2.49)	1.107	.623
663	23	.057 (3.50)	.782 (9.13)	.051 (0.96)	−.449 (2.41)	1.083	.626
664	24	.084 (4.70)	.625 (7.06)	.162 (3.24)	−.289 (1.48)	1.224	.550
671	25	.074 (4.93)	.681 (9.45)	.124 (3.30)	−.439 (2.44)	1.224	.552
672	26	.070 (5.10)	.703 (11.10)	.111 (3.60)	−.412 (2.31)	1.205	.552
673	27	.073 (5.32)	.686 (11.02)	.123 (4.34)	−.396 (2.24)	1.206	.536
674	28	.071 (4.60)	.690 (9.85)	.131 (4.15)	−.324 (1.82)	1.294	.553
681	29	.081 (5.45)	.651 (9.53)	.137 (4.31)	−.487 (3.00)	1.450	.568
682	30	.083 (5.39)	.641 (8.99)	.138 (4.18)	−.401 (2.40)	1.436	.559
683	31	.084 (5.52)	.641 (9.16)	.137 (4.26)	−.405 (2.46)	1.411	.578
684	32	.083 (5.46)	.639 (9.07)	.144 (4.48)	−.419 (2.61)	1.438	.553
691	33	.083 (5.42)	.639 (9.02)	.146 (4.53)	−.391 (2.44)	1.422	.559
692	34	.083 (5.50)	.639 (9.17)	.146 (4.62)	−.392 (2.48)	1.400	.562
693	35	.081 (5.37)	.646 (9.23)	.146 (4.59)	−.388 (2.49)	1.403	.547
694	36	.081 (5.40)	.646 (9.30)	.147 (4.67)	−.381 (2.47)	1.383	.550

so the first estimate was based on only 19 observations. As usual, the observations for 644, 651, and 652 were omitted from the sample periods because of the automobile strike.

The estimates in Table 12–2 are reasonably stable from 681 through 694, but less so from 653 to 681. The coefficient estimate of GNP went from .048 for the period ending in 653 to .081 for the period ending in 681 and then stabilized around .08; the coefficient estimate of CN_{t-1} went from .810 to .651 during this period and then stabilized around .64 or 65; the coefficient estimate of $MOOD_{t-2}$ went from .059 to .137 and then stabilized around .14 or .15; and the estimate of the serial correlation coefficient went from −.548 to −.487 and then stabilized around −.40 or −.39. The results are therefore only moderately good, but the fact that the estimates since 681 have been fairly stable is somewhat encouraging. Remember, however, that the reason the longer sample period was not used for the nondurable equation was because there appeared to be a shift in the aggregate relationship between 561 and 602. This, of course, further limits the confidence that one can place on the assumption that the relationship will be stable in the future.

Consumption of Services

In Table 12–3 the results of estimating equation (3.11) for the eighteen sample periods are presented. For this equation the longer period was used. From Table 12–3 there appears to be no serious instability in the services equation. The coefficient estimate of GNP_t has appeared to stabilize around .02, the coefficient estimate of CS_{t-1} around .94, the coefficient estimate of $MOOD_{t-2}$ around −.02, and the estimate of the serial correlation coefficient around −.07.

Plant and Equipment Investment

In Table 12–4 the results of estimating equation (4.4) for the eighteen sample periods are presented. The stability of the equation appears to be reasonable. The estimate of the coefficient of GNP_t has varied between .051 and .063, the estimate of the coefficient of $PE2_t$ between .687 and .841, and the estimate of the serial correlation coefficient between .600 and .757.

Equation (4.4) uses the two-quarter-ahead expectation variable. As discussed in Chapter 4, an equation, equation (4.7), was also estimated using the one-quarter-ahead expectation variable. Although equation (4.7) is not used for any of the work in this chapter, it will be used for some of the work in the next chapter, and so the stability of the equation was examined in the same way as the others. The eighteen estimates of equation (4.7) are presented in Table 12–5. A similar conclusion emerges from Table 12–5 as emerged from Table 12–4: the coefficient estimates appear to be reasonably stable. The coefficient estimate of GNP_t is the most stable, with a range of only .042 to .048.

Table 12–3. Coefficient Estimates of Equation (3.11) for Eighteen Sample Periods. (Dependent variable is CS_t.)

End of Sample Period	No. of Observations	Coefficient Estimates for $\widehat{GNP}_t$	CS_{t-1}	$MOOD_{t-2}$	$\hat{r}$	SE	$R\Delta^2$
653	33	.029 (3.75)	.920 (35.59)	−.028 (3.45)	−.184 (1.07)	.392	.614
654	34	.029 (4.11)	.921 (38.87)	−.028 (3.88)	−.189 (1.12)	.387	.657
661	35	.024 (3.74)	.935 (41.70)	−.023 (3.55)	−.158 (.94)	.394	.663
662	36	.019 (2.90)	.953 (42.13)	−.017 (2.74)	−.094 (.57)	.410	.642
663	37	.016 (2.61)	.962 (44.07)	−.014 (2.50)	−.057 (.35)	.411	.658
664	38	.014 (2.42)	.969 (46.64)	−.012 (2.34)	−.037 (.23)	.413	.670
671	39	.017 (3.11)	.959 (48.46)	−.015 (3.43)	−.080 (.50)	.419	.723
672	40	.017 (3.21)	.959 (48.79)	−.016 (3.82)	−.067 (.42)	.414	.751
673	41	.019 (3.38)	.955 (46.75)	−.019 (4.50)	−.061 (.39)	.430	.777
674	42	.019 (3.43)	.955 (47.33)	−.019 (4.73)	−.059 (.38)	.425	.795
681	43	.019 (3.57)	.953 (47.77)	−.020 (5.16)	−.061 (.40)	.422	.816
682	44	.020 (3.79)	.950 (48.04)	−.021 (5.76)	−.050 (.33)	.419	.838
683	45	.023 (4.03)	.940 (43.46)	−.024 (6.39)	−.011 (.07)	.444	.850
684	46	.022 (4.13)	.942 (46.03)	−.023 (6.59)	−.072 (.49)	.446	.853
691	47	.022 (4.02)	.944 (46.12)	−.022 (6.72)	−.068 (.46)	.442	.864
692	48	.022 (4.10)	.944 (46.58)	−.023 (7.03)	−.068 (.47)	.437	.876
693	49	.022 (4.13)	.944 (46.94)	−.022 (7.12)	−.070 (.49)	.434	.882
694	50	.022 (4.15)	.945 (47.77)	−.023 (7.37)	−.077 (.55)	.431	.891

Table 12–4. Coefficient Estimates of Equation (4.4) for Eighteen Sample Periods. (Dependent variable is IP_t.)

End of Sample Period	No. of Observations	Constant	$\widehat{GNP}_t$	$PE2_t$	$\hat{\rho}$	SE	$R\Delta^2$
653	33	−10.47	.057	.816	.600	.721	.749
		(4.29)	(10.98)	(10.23)	(4.21)		
654	34	−13.29	.061	.841	.668	.745	.761
		(5.25)	(9.95)	(10.17)	(5.29)		
661	35	−11.53	.059	.828	.621	.757	.757
		(5.69)	(10.32)	(11.42)	(4.69)		
662	36	−10.72	.059	.803	.631	.756	.751
		(5.63)	(10.16)	(11.54)	(4.87)		
663	37	−10.62	.059	.789	.645	.743	763
		(5.80)	(10.17)	(11.97)	(5.14)		
664	38	−10.01	.062	.742	.691	.748	.753
		(5.01)	(9.52)	(10.78)	(5.90)		
671	39	−9.48	.063	.708	.729	.756	.751
		(4.30)	(8.86)	(9.70)	(6.66)		
672	40	−9.28	.062	.709	.733	.747	.753
		(4.34)	(9.02)	(9.77)	(6.81)		
673	41	−8.49	.062	.696	.757	.758	.739
		(3.72)	(8.46)	(9.12)	(7.41)		
674	42	−8.73	.062	.699	.747	.750	.740
		(4.23)	(9.07)	(9.46)	(7.29)		
681	43	−9.35	.062	.715	.725	.756	.759
		(5.02)	(9.41)	(9.92)	(6.90)		
682	44	−6.83	.052	.794	.667	.917	.679
		(3.79)	(7.51)	(10.01)	(5.93)		
683	45	−6.02	.051	.782	.721	.926	.667
		(2.91)	(6.74)	(9.07)	(6.97)		
684	46	−7.27	.054	.769	.637	.978	.642
		(4.43)	(8.14)	(9.63)	(5.61)		
691	47	−6.71	.056	.728	.650	.989	.650
		(3.90)	(8.17)	(9.20)	(6.05)		
692	48	−7.27	.058	.727	.643	.998	.643
		(4.53)	(8.60)	(9.30)	(5.80)		
693	49	−7.44	.058	.730	.643	.989	.656
		(4.81)	(8.68)	(9.47)	(5.88)		
694	50	−8.50	.063	.687	.689	1.011	.633
		(4.86)	(8.87)	(8.34)	(6.72)		

Table 12–5. Coefficient Estimates of Equation (4.7) for Eighteen Sample Periods. (Dependent variable is IP_t.)

End of Sample Period	No. of Observations	Coefficient Estimates for Constant	$\widehat{GNP}_t$	PEI_t	$\hat{r}$	SE	$R\Delta^2$
653	33	−8.64	.046	.927	.399	.647	.798
		(5.61)	(12.57)	(15.22)	(2.50)		
654	34	−9.16	.046	.941	.425	.640	.823
		(6.97)	(12.36)	(17.43)	(2.74)		
661	35	−9.17	.046	.940	.426	.630	.831
		(8.00)	(12.60)	(19.10)	(2.78)		
662	36	−8.39	.047	.914	.438	.644	.819
		(7.70)	(12.28)	(19.20)	(2.92)		
663	37	−8.40	.047	.913	.438	.634	.827
		(8.31)	(12.48)	(20.47)	(2.96)		
664	38	−8.17	.047	.903	.456	.630	.825
		(8.31)	(12.30)	(20.42)	(3.16)		
671	39	−7.70	.048	.880	.507	.649	.816
		(7.16)	(11.16)	(18.20)	(3.67)		
672	40	−7.57	.048	.875	.526	.642	.818
		(7.10)	(10.99)	(17.76)	(3.91)		
673	41	−6.94	.048	.856	.590	.671	.796
		(5.64)	(9.48)	(15.08)	(4.67)		
674	42	−7.17	.048	.860	.558	.667	.794
		(6.55)	(10.29)	(16.04)	(4.36)		
681	43	−7.42	.048	.863	.545	.664	.814
		(7.22)	(10.60)	(16.55)	(4.20)		
682	44	−5.95	.043	.897	.498	.839	.731
		(5.30)	(8.29)	(14.73)	(3.81)		
683	45	−5.65	.042	.899	.542	.834	.730
		(4.82)	(7.77)	(13.93)	(4.33)		
684	46	−5.58	.042	.899	.551	.825	.745
		(4.86)	(7.72)	(13.85)	(4.48)		
691	47	−5.14	.043	.879	.593	.834	.751
		(4.12)	(7.28)	(12.91)	(5.05)		
692	48	−5.43	.043	.882	.561	.833	.751
		(4.83)	(7.76)	(13.56)	(4.70)		
693	49	−6.11	.045	.876	.549	.877	.730
		(5.49)	(7.90)	(13.05)	(4.60)		
694	50	−6.36	.046	.874	.572	.873	.727
		(5.59)	(7.76)	(12.65)	(4.94)		

Housing Investment

In Table 12–6 the results of estimating equation (5.5) for the eighteen sample periods are presented. Due to lack of data on housing starts before 1959, the shorter period of estimation was used for this equation. The seasonal adjustment coefficients that were used for HSQ were calculated using data only through 652 to insure that information beyond the sample period was not used. As mentioned in Chapter 5, the seasonal adjustment coefficients were actually quite stable for changes in the sample period.

Aside from the estimates of the constant term and the serial correlation coefficient, the coefficient estimates in Table 12–6 are fairly stable. The first six estimates (through the sample period ending in 664) of the coefficient of HSQ_{t-1} are lower than the others, but after 664 the estimates appear to have stabilized. The estimate of the constant term has, in general, been decreasing over time, but the estimate has only been significant since 691. The estimate of the serial correlation coefficient has not been very stable and has ranged from a low of .132 to a high of .573. Given the nonstructural nature of equation (5.5), it it not too surprising that some of the coefficient estimates are unstable, but the overall results in Table 12–6 do not appear too unreasonable.

Inventory Investment

In Table 12–7 the results of estimating equation (6.15) for the eighteen samples periods are presented. The estimates have been fairly stable since 681, but less so before that. In particular, the estimate of the coefficient of $CD_{t-1} + CN_{t-1} - CD_t - CN_t$ (which is the same as the estimate of the coefficient of $-CD_t - CN_t$, since $CD_{t-1} + CN_{t-1}$ is included as a separate explanatory variable in the equation) was negative, with one exception, before 681. Also, the estimate of the coefficient of V_{t-1} was larger in absolute value, with one exception, before 681 than after. The estimates were changed a lot in 664, which was the quarter in which inventory investment was 19.9 billion dollars, and in 681, which was a quarter in which inventory investment was only 1.6 billion dollars. In general, however, the results in Table 12–7 appear to be reasonable, especially considering the highly volatile nature of the inventory investment series.

Imports

In Table 12–8 the results of estimating equation (7.3) for fourteen sample periods are presented. Since the observations for 653 were omitted from the

Table 12–6. Coefficient Estimates of Equation (5.5) for Eighteen Sample Periods. (Dependent variable is IH_t.)

End of Sample Period	No. of Observations	Coefficient Estimates for							
		Constant	$\widehat{GNP}_t$	HSQ_t	HSQ_{t-1}	HSQ_{t-2}	$\hat{r}$	SE	$R\Delta^2$
653	19	.37	.018	.0218	.0152	.0030	.280	.333	.830
		(.30)	(5.08)	(4.78)	(2.81)	(0.61)	(1.27)		
654	20	.87	.016	.0211	.0181	.0033	.233	.331	.820
		(.84)	(6.63)	(4.85)	(4.08)	(0.71)	(1.07)		
661	21	.93	.015	.0214	.0180	.0017	.226	.322	.819
		(.95)	(8.41)	(5.19)	(4.20)	(0.85)	(1.06)		
662	22	1.09	.013	.0235	.0206	.0016	.177	.352	.821
		(1.08)	(8.17)	(5.45)	(4.49)	(0.35)	(.84)		
663	23	1.16	.013	.0228	.0207	.0017	.160	.343	.840
		(1.20)	(9.30)	(6.06)	(4.57)	(0.38)	(.78)		
664	24	.90	.013	.0231	.0235	.0008	.132	.359	.880
		(.94)	(9.23)	(5.93)	(5.28)	(0.17)	(.65)		
671	25	.66	.011	.0192	.0262	.0052	.267	.372	.865
		(.57)	(8.68)	(5.62)	(6.79)	(1.26)	(1.39)		
672	26	.70	.011	.0183	.0258	.0072	.318	.368	.879
		(.57)	(9.10)	(5.81)	(7.02)	(2.32)	(1.71)		
673	27	.34	.012	.0197	.0270	.0040	.172	.419	.889
		(.30)	(11.33)	(5.64)	(5.93)	(1.16)	(.91)		
674	28	−2.77	.014	.0212	.0268	.0069	.573	.469	.874
		(1.38)	(7.41)	(5.31)	(6.46)	(1.77)	(3.70)		
681	29	−.38	.012	.0217	.0261	.0037	.245	.479	.863
		(.29)	(11.22)	(5.52)	(5.28)	(0.94)	(1.36)		
682	30	−1.27	.013	.0221	.0259	.0046	.258	.511	.847
		(.95)	(12.02)	(5.28)	(4.95)	(1.11)	(1.46)		
683	31	−1.26	.013	.0221	.0259	.0046	.256	.501	.848
		(1.01)	(13.09)	(5.40)	(5.05)	(1.14)	(1.48)		
684	32	−2.32	.014	.0240	.0248	.0053	.308	.539	.830
		(1.72)	(12.88)	(5.57)	(4.64)	(1.22)	(1.83)		
691	33	−3.34	.015	.0241	.0257	.0057	.430	.547	.823
		(2.24)	(11.81)	(5.47)	(5.08)	(1.30)	(2.74)		
692	34	−3.11	.015	.0245	.0254	.0053	.400	.539	.825
		(2.30)	(13.07)	(5.75)	(5.09)	(1.24)	(2.55)		
693	35	−3.18	.015	.0243	.0254	.0056	.407	.530	.833
		(2.40)	(13.83)	(5.94)	(5.19)	(1.38)	(2.64)		
694	36	−3.53	.016	.0242	.0230	.0074	.449	.582	.792
		(2.31)	(13.12)	(5.37)	(4.45)	(1.66)	(3.01)		

Table 12–7. Coefficient Estimates of Equation (6.15) for Eighteen Sample Periods. (Dependent variable is $V_t - V_{t-1}$.)

End of Sample Period	No. of Observations	Constant	Coefficient Estimates for $CD_{t-1} + CN_{t-1}$	V_{t-1}	$CD_{t-1} + CN_{t-1} - \widehat{CD}_t - \widehat{CN}_t$	$\hat{r}$	SE	$R\Delta^2$
653	33	−155.06	.986	−.542	−.387	.855	2.027	.527
		(4.53)	(4.72)	(4.49)	(1.61)	(9.45)		
654	34	−153.12	.974	−.533	−.361	.852	1.993	.527
		(4.63)	(4.78)	(4.42)	(1.50)	(9.48)		
661	35	−152.53	.971	−.533	−.362	.851	1.960	.532
		(4.87)	(4.97)	(4.50)	(1.52)	(9.57)		
662	36	−165.22	1.026	−.515	−.319	.868	2.171	.458
		(4.55)	(4.62)	(4.00)	(1.26)	(10.49)		
663	37	−160.54	.989	−.484	−.349	.872	2.159	.483
		(4.62)	(4.75)	(4.25)	(1.40)	(10.83)		
664	38	−126.89	.772	−.327	.042	.842	2.498	.410
		(3.43)	(3.44)	(2.73)	(.17)	(9.61)		
671	39	−159.13	.967	−.433	−.084	.869	2.511	.540
		(4.75)	(5.00)	(4.65)	(.34)	(10.96)		
672	40	−158.74	.976	−.454	−.113	.868	2.547	.542
		(4.82)	(5.05)	(4.83)	(.43)	(10.12)		
673	41	−163.24	.999	−.457	−.087	.859	2.522	.556
		(4.89)	(5.14)	(4.88)	(.34)	(10.74)		
674	42	−178.61	1.071	−.468	−.208	.890	2.610	.515
		(4.72)	(4.99)	(4.74)	(.76)	(12.68)		
681	43	−133.15	.829	−.385	.103	.778	2.627	.547
		(4.58)	(4.72)	(4.31)	(.49)	(8.11)		
682	44	−117.55	.737	−.345	.084	.743	2.629	.584
		(4.53)	(4.66)	(4.15)	(.40)	(7.36)		
683	45	−111.78	.704	−.332	.143	.742	2.606	.585
		(4.46)	(4.60)	(4.08)	(.72)	(7.42)		
684	46	−113.89	.719	−.344	.085	.757	2.612	.581
		(4.41)	(4.56)	(4.11)	(.43)	(7.86)		
691	47	−107.68	.682	−.327	.168	.760	2.569	.593
		(4.07)	(4.23)	(3.81)	(.81)	(8.01)		
692	48	−105.30	.670	−.326	.171	.777	2.570	.584
		(3.96)	(4.13)	(3.74)	(.82)	(8.55)		
693	49	−109.79	.697	−.339	.131	.777	2.552	.589
		(3.98)	(4.15)	(3.77)	(.59)	(8.65)		
694	50	−114.76	.728	−.357	.095	.791	2.540	.589
		(4.09)	(4.27)	(3.94)	(.42)	(9.15)		

Table 12–8. Coefficient Estimates of Equation (7.3) for Fourteen Sample Periods. (Dependent variable is IMP_t.)

End of Sample Period	No. of Obser-vations	Coefficient Estimate for $\widehat{GNP}_t$	$\hat{r}$	SE	$R\Delta^2$
643	32	.051 (4.58)	1.0	.514	.268
654	33	.050 (4.65)	1.0	.515	.325
661	34	.054 (5.44)	1.0	.512	.378
662	35	.055 (5.86)	1.0	.507	.395
663	36	.063 (6.20)	1.0	.554	.390
664	37	.061 (6.28)	1.0	.549	.384
671	38	.061 (6.40)	1.0	.544	.380
672	39	.059 (6.09)	1.0	.555	.356
673	40	.057 (6.18)	1.0	.552	.347
674	41	.063 (6.79)	1.0	.573	.371
681	42	.075 (7.61)	1.0	.634	.403
682	43	.073 (8.00)	1.0	.628	.417
683	44	.078 (8.51)	1.0	.644	.437
694	45	.078 (8.70)	1.0	.637	.437

sample period for the import equation, the first estimate presented in Table 12–8 is for the period ending in 643. The second estimate is then for the period ending in 654. Observations for 684, 691, 692, and 693 were also omitted from the sample period for the import equation, and thus the penultimate estimate presented in the table is for the period ending in 683 and the last estimate is for the period ending in 694.

As can be seen from the results in Table 12–8, the estimate of the coefficient of GNP_t has been increasing through time—from .051 for the period ending in 643 to .078 for the period ending in 694. The estimate was changed a lot in 681, which corresponded to an increase in imports of 3.1 billion dollars. The overall results indicate that the import equation is not stable through time, but that the movement of the coefficient estimate over time is fairly smooth.

Employment

The results of estimating equation (9.8) for the eighteen sample periods are presented in Table 12–9. In order to estimate equation (9.8), estimates of the production function parameter α_t first have to be made. For the work in Chapter 9, α_t was estimated from peak-to-peak interpolations of the output per paid-for man-hour series in Figure 9-1. Two of the peaks that were used for this purpose were the peaks in 661 and 684, and so theoretically neither of these peak observations should be used for the estimates through 654. Likewise, the 684 peak observation should not be used for the estimates through 683. In practice, however, both of these peak observations were used for the estimates presented in Table 12–9. In particular, the estimates of α_t that were made in Chapter 9 were used for the work here. Since the slopes of the last two interpolation lines in Figure 9–1 are nearly the same, the results presented in Table 12–9 are nearly the same as the results that would have been achieved had the 684 peak observation not been used. Likewise, the results for 653 and 654 would have been only slightly different had the 661 peak observation not been used.

Aside from the estimate of the coefficient of the time trend in Table 12–9, the estimates of the employment equation are quite stable. The estimate of the coefficient of the time trend has, in general, been increasing over time, but it has always been small and not significant. The employment equation appears to pose no serious stability problems.

The D_t Equation

The results of estimating equation (9.10) for the eighteen sample periods are presented in Table 12–10. Equation (9.10) is the equation explaining the difference between the establishment employment data and the household survey employment data. Aside from the estimates for the first three periods, the estimates in Table 12–10 are quite stable. During the first three periods, the estimates increased slightly in absolute value.

Table 12–9. Coefficient Estimates of Equation (9.8) for Eighteen Sample Periods. (Dependent variable is $\log M_t - \log M_{t-1}$.)

End of Sample Period	No. of Observations	Constant	Coefficient Estimates for t	$\log M_{t-1} - \log M_{t-1}H_{t-1}$	$\log Y_t - \log Y_{t-1}$	$\log Y_{t-1} - \log Y_{t-2}$	$\hat{r}$	SE	R^2
653	33	−.550	.0000099	−.151	.337	.134	.303	.00344	.805
		(2.94)	(.11)	(2.94)	(6.11)	(2.17)	(1.83)		
654	34	−.535	.0000024	−.147	.335	.136	.301	.00339	.813
		(3.02)	(.03)	(3.02)	(6.21)	(2.23)	(1.84)		
661	35	−.493	−.0000180	−.136	.334	.139	.297	.00337	.813
		(2.91)	(.24)	(2.91)	(6.22)	(2.31)	(1.84)		
662	36	−.511	−.0000075	−.141	.332	.137	.291	.00333	.816
		(3.21)	(.11)	(3.21)	(6.29)	(2.32)	(1.83)		
663	37	−.562	.0000182	−.154	.330	.120	.325	.00333	.814
		(3.46)	(.26)	(3.44)	(6.24)	(2.07)	(2.09)		
664	38	−.529	.0000004	−.145	.330	.133	.278	.00332	.810
		(3.51)	(.01)	(3.49)	(6.28)	(2.33)	(1.78)		
671	39	−.534	.0000189	−.147	.317	.132	.270	.00331	.805
		(3.59)	(.32)	(3.57)	(6.28)	(2.33)	(1.75)		
672	40	−.529	.0000150	−.145	.317	.137	.262	.00327	.806
		(3.67)	(.28)	(3.65)	(6.37)	(2.54)	(1.71)		

673	41	−.530	.0000107	−.146	.317	.138	.262	.00322	.805
		(3.73)	(.21)	(3.71)	(6.45)	(2.60)	(1.74)		
674	42	−.525	.0000215	−.144	.315	.140	.253	.00321	.803
		(3.75)	(.44)	(3.72)	(6.44)	(2.64)	(1.69)		
681	43	−.525	.0000231	−.144	.315	.139	.255	.00317	.804
		(3.79)	(.49)	(3.76)	(6.53)	(2.67)	(1.73)		
682	44	−.525	.0000208	−.144	.314	.139	.254	.00313	.806
		(3.84)	(.46)	(3.82)	(6.61)	(2.71)	(1.74)		
683	45	−.529	.0000110	−.145	.319	.134	.260	.00312	.802
		(3.85)	(.25)	(3.83)	(6.79)	(2.62)	(1.81)		
684	46	−.529	.0000160	−.145	.319	.132	.251	.00309	.801
		(3.95)	(.39)	(3.92)	(6.85)	(2.64)	(1.76)		
691	47	−.534	.0000396	−.146	.309	.128	.269	.00322	.784
		(3.73)	(.93)	(3.70)	(6.39)	(2.44)	(1.91)		
692	48	−.537	.0000489	−.147	.306	.123	.309	.00320	.782
		(3.58)	(1.14)	(3.55)	(6.39)	(2.35)	(2.25)		
693	49	−.529	.0000564	−.145	.303	.121	.325	.00318	.781
		(3.51)	(1.34)	(3.48)	(6.41)	(2.33)	(2.41)		
694	50	−.514	.0000643	−.140	.298	.121	.336	.00316	.778
		(3.44)	(1.57)	(3.41)	(6.43)	(2.34)	(2.52)		

Table 12–10. Coefficient Estimates of Equation (9.10) for Eighteen Sample Periods. (Dependent variable is D_t.)

End of Sample Period	No. of Obser-vations	Coefficient Estimates for Constant	t	M_t	$\hat{r}$	SE	$R\Delta^2$
653	33	−10086 (4.01)	−65.18 (6.70)	.300 (5.73)	.491 (3.24)	167.8	.539
654	34	−11095 (4.95)	−67.13 (7.03)	.319 (6.75)	.505 (3.42)	166.8	.555
661	35	−12156 (5.74)	−69.40 (7.02)	.341 (7.51)	.536 (3.76)	166.6	.559
662	36	−13747 (6.41)	−73.12 (6.61)	.373 (7.97)	.594 (4.43)	169.7	.557
663	37	−14408 (6.97)	−74.87 (6.44)	.386 (8.43)	.625 (4.88)	168.1	.560
664	38	−14096 (7.37)	−74.19 (6.70)	.380 (8.88)	.609 (4.73)	166.1	.561
671	39	−14497 (7.74)	−74.88 (6.65)	.388 (9.10)	.620 (4.93)	165.1	.557
672	40	−14713 (7.90)	−75.03 (6.56)	.392 (9.24)	.631 (5.14)	163.5	.553
673	41	−14118 (8.14)	−74.19 (6.98)	.380 (9.61)	.594 (4.73)	166.5	.548
674	42	−14072 (8.41)	−74.12 (7.06)	.379 (9.87)	.595 (4.80)	164.3	.550
681	43	−14466 (8.87)	−74.79 (7.16)	.387 (10.26)	.587 (4.76)	164.9	.554
682	44	−14384 (9.30)	−74.52 (7.37)	.385 (10.71)	.584 (4.77)	162.9	.554
683	45	−14482 (9.58)	−74.70 (7.43)	.387 (10.95)	.586 (4.86)	161.2	.553
684	46	−14534 (9.87)	−74.83 (7.51)	.388 (11.21)	.588 (4.93)	159.3	.553
691	47	−13820 (9.76)	−72.35 (7.40)	.373 (11.14)	.567 (4.72)	163.9	.521
692	48	−14157 (10.71)	−73.16 (7.92)	.380 (12.08)	.539 (4.43)	164.7	.531
693	49	−13510 (10.25)	−71.27 (7.65)	.367 (11.65)	.519 (4.25)	173.8	.501
694	50	−13014 (8.23)	−71.10 (6.15)	.358 (9.39)	.600 (5.30)	181.4	.460

The Primary Labor Force

The results of estimating equation (9.11) for the eighteen sample periods are presented in Table 12–11. The labor force participation of primary workers is explained merely by a constant and a time trend, and thus the results in Table 12–11 are not very interesting. The estimate of the coefficient of the time trend is fairly stable, although it has been increasing slightly in absolute value in the last three quarters.

The Secondary Labor Force

The results of estimating equation (9.12) for the eighteen sample periods are presented in Table 12-12. The estimate of the coefficient of the time trend has been increasing over time—from .000120 for the period ending in 653 to .000523 for the period ending in 694—and the estimate of the serial correlation coefficient has been increasing over time—from .398 for the period ending in 653 to .797 for the period ending in 694. The estimate of the coefficient of the $(E_t + AF_t)/(P_{1t} + P_{2t})$ rose from .241 in 653 to .425 in 664 and stabilized after that.

The labor force participation of secondary workers has risen very sharply since 1965, and equation (9.12) does not appear to be capable of accounting for this rise in any satisfactory way. Even after 664, when the coefficient estimate of $(E_t + AF_t)/(P_{1t} + P_{2t})$ stabilized, the coefficient estimate of the time trend continued to rise. There are obviously factors affecting the labor force participation of secondary workers that have been excluded from equation (9.12), and these factors appear to have been quite important in the last few years. The rise in the labor force participation of secondary workers cannot be explained merely by the rise in the employment–population ratio.

It will be seen below that the use of the results in Table 12–12 has caused the model to consistently underpredict the growth of the labor force and thus underpredict the unemployment rate. This is one of the more serious problems in the model, but given the purpose of the present study, it is not clear that much can be done about it. As mentioned in Chapter 9, the factors that are likely to influence the labor force participation of secondary workers have been discussed by Mincer [37], but these factors would be difficult to incorporate into a short-run forecasting model. Also, the disaggregation that should be made in any detailed study of labor force participation rates is beyond the scope of the present study. Consequently, equation (9.12) has been chosen to be used in the model, but unless the equation is more stable in the future than it has been in the past, it will continue to be one of the weaker equations of the model.

Table 12–11. Coefficient Estimates of Equation (9.11) for Eighteen Sample Periods. (Dependent variable is LF_{1t}/P_{1t}.)

End of Sample Period	No. of Obser-vations	Coefficient Estimates for Constant	t	$\hat{r}$	SE	$R\Delta^2$
653	33	.980	−.000177	.180	.00201	.540
		(450.34)	(4.50)	(1.05)		
654	34	.980	−.000177	.180	.00197	.540
		(476.52)	(4.88)	(1.07)		
661	35	.980	−.000171	.179	.00195	.539
		(500.01)	(5.02)	(1.08)		
662	36	.980	−.000169	.180	.00192	.539
		(524.29)	(5.25)	(1.10)		
663	37	.980	−.000172	.180	.00190	.538
		(549.77)	(5.68)	(1.11)		
664	38	.980	−.000164	.173	.00189	.538
		(571.33)	(5.70)	(1.08)		
671	39	.979	−.000150	.194	.00195	.509
		(556.45)	(5.11)	(1.24)		
672	40	.979	−.000150	.193	.00192	.520
		(580.40)	(5.40)	(1.25)		
673	41	.979	−.000154	.191	.00191	.519
		(603.18)	(5.83)	(1.25)		
674	42	.979	−.000158	.195	.00189	.516
		(621.50)	(6.19)	(1.29)		
681	43	.979	−.000154	.191	.00187	.520
		(645.63)	(6.37)	(1.27)		
682	44	.980	−.000158	.188	.00186	.519
		(667.98)	(6.84)	(1.27)		
683	45	.980	−.000163	.196	.00185	.511
		(678.89)	(7.23)	(1.34)		
684	46	.980	−.000169	.210	.00185	.500
		(681.18)	(7.57)	(1.46)		
691	47	.980	−.000166	.201	.00184	.511
		(708.27)	(7.83)	(1.41)		
692	48	.980	−.000175	.196	.00188	.495
		(711.29)	(8.37)	(1.38)		
693	49	.981	−.000181	.226	.00189	.478
		(693.30)	(8.53)	(1.63)		
694	50	.981	−.000190	.265	.00193	.447
		(658.38)	(8.57)	(1.94)		

Table 12–12. Coefficient Estimates of Equation (9.12) for Eighteen Sample Periods. (Dependent variable is LF_{2t}/P_{2t}.)

End of Sample Period	No. of Observations	Coefficient Estimates for: Constant	t	$(E_t + AF_t)/(P_{1t} + P_{2t})$	$\hat{\rho}$	SE	$R\Delta^2$
653	33	.319	.000120	.241	.398	00219	.495
		(5.44)	(1.60)	(2.41)	(2.49)		
654	34	.295	.000155	.279	.425	.00218	.489
		(5.32)	(2.27)	(2.99)	(2.74)		
661	35	.282	.000174	.301	.440	.00215	.485
		(5.42)	(2.80)	(3.41)	(2.90)		
662	36	.259	.000209	.338	.465	.00217	.473
		(5.12)	(3.51)	(3.92)	(3.15)		
663	37	.229	.000252	.387	.510	.00222	.452
		(4.43)	(4.10)	(4.37)	(3.60)		
664	38	.206	.000290	.425	.562	.00225	.435
		(3.88)	(4.44)	(4.63)	(4.19)		
671	39	.200	.000307	.433	.590	.00224	.427
		(3.76)	(4.65)	(4.68)	(4.57)		
672	40	.197	.000323	.437	.613	.00222	.419
		(3.63)	(4.84)	(4.61)	(4.91)		
673	41	.189	.000364	.446	.661	.00229	.398
		(3.22)	(4.84)	(4.33)	(5.63)		
674	42	.196	.000407	.430	.719	.00232	.373
		(3.03)	(4.53)	(3.75)	(6.70)		
681	43	.194	.000393	.436	.700	.00229	.388
		(3.15)	(4.83)	(4.00)	(6.43)		
682	44	.186	.000415	.447	.716	.00229	.384
		(3.01)	(4.94)	(4.08)	(6.80)		
683	45	.186	.000414	.447	.714	.00226	.391
		(3.07)	(5.13)	(4.13)	(6.85)		
684	46	.187	.000412	.446	.713	.00224	.393
		(3.15)	(5.30)	(4.20)	(6.90)		
691	47	.166	.000430	.480	.712	.00225	.413
		(2.90)	(5.53)	(4.66)	(6.95)		
692	48	.167	.000450	.478	.732	.00225	.402
		(2.81)	(5.55)	(4.48)	(7.44)		
693	49	.169	.000488	.471	.767	.00228	.386
		(2.65)	(5.21)	(4.09)	(8.36)		
694	50	.180	.000523	.447	.797	.00228	.373
		(2.69)	(4.97)	(3.67)	(9.32)		

Prices

The results of estimating the price equation for the eighteen sample periods are presented in Table 12–13. It was mentioned in Chapter 10, and is discussed in more detail in Fair [15], that only since about 1968 or 1969 has the nonlinearity in the price relationship become apparent. Before 1968 or 1969 there was little evidence of anything but a linear relationship. Indeed, for most of the sample periods ending before 1969 it was not possible to get the coefficient estimates of equation (10.7) to converge. Consequently, for the work here the linear version of equation (10.7) was used for the estimates through 684, and only for the last four sample periods (ending in 691, 692, 693, and 694 respectively) was the nonlinear version used.

In order to estimate the price equation, estimates of potential GNP have to be made. As discussed in Chapter 10, the estimates of potential GNP are based on (1) the estimate of the production function parameter α_t from Chapter 9; (2) the peak-to-peak interpolations of the agricultural output series, YA_t, and the agricultural "productivity" series, YA_t/MA_t; (3) the coefficient estimates of the two labor force participation equations and of the D_t equation; and (4) the coefficient estimates of the HP_t regression in (10.2). In computing the estimates of potential GNP for the work in this chapter, the estimates of α_t from Chapter 9 were used, as well as peak-to-peak interpolations of the two agricultural series from Chapter 10. As discussed above for the employment equation, the results would have been only slightly changed if the 661 and 684 peaks had not been used in the estimation of α_t. Likewise, the results would have been only slightly changed had the interpolations of the two agricultural series been based only on information before 653. The estimates of the HP_t regression in (10.2) were also used for work here, since there would have been very little difference in results had only information before 653 been used to estimate (10.2). With respect to the coefficient estimates of the labor force participation equations and of the D_t equation, the estimates of potential GNP in this chapter were based only on the coefficient estimates that would have been available at the time the price equation would have been estimated. Each of the estimates in Table 12–13 is thus based on a slightly different potential GNP series. Again, however, it makes little difference which set of coefficient estimates is used to estimate the potential GNP series. Different sets of coefficient estimates primarily influence the overall level of the potential GNP series and have little influence on the change in the series. Since any "errors" made in estimating the level of potential GNP are absorbed in the estimate of the constant term in the price equation, it makes little difference which set of coefficient estimates is used.

Table 12–13. Coefficient Estimates of the Price Equation for Eighteen Sample Periods. (Dependent variable is $PD_t - PD_{t-1}$.)

End of Sample Period	No. of Obser-vations	Linear Version Coefficient Estimates for Constant	$\frac{1}{8}\sum_{i=1}^{8} GAP2_{t-i+1}$	Nonlinear Version Equation (10.7) $\hat{a}_0$	$\hat{a}_1$	$\hat{a}_2$	SE	R^2	DW
653	33	1.044 (10.45)	−.0189 (6.51)				.191	.577	2.15
654	34	1.002 (10.22)	−.0174 (6.23)				.194	.548	1.88
661	35	1.018 (11.21)	−.0174 (6.82)				.187	.585	2.05
662	36	1.076 (12.57)	−.0180 (7.77)				.183	.640	2.08
663	37	1.087 (13.60)	−.0176 (8.35)				.179	.666	2.17
664	38	1.073 (14.52)	−.0171 (8.74)				.177	.680	2.14
671	39	.969 (14.03)	−.0154 (7.86)				.189	.625	1.88
672	40	.959 (13.43)	−.0140 (7.40)				.196	.590	1.68
673	41	.975 (14.89)	−.0145 (8.19)				.193	.632	1.86
674	42	.978 (16.25)	−.0146 (8.86)				.189	.662	1.89
681	43	.977 (17.24)	−.0144 (9.28)				.187	.677	1.89
682	44	.991 (18.55)	−.0147 (9.96)				.185	.703	1.90
683	45	.987 (19.65)	−.0146 (10.41)				.183	.716	1.91
684	46	.966 (20.97)	−.0148 (11.06)				.182	.735	1.91
691	47			−3.648 (.61)	1179.9 (.36)	251.9 (.65)	.185	.757	1.85
692	48			−1.527 (1.13)	286.5 (.80)	109.8 (1.37)	.187	.778	1.76
693	49			−1.128 (1.35)	186.0 (1.07)	83.8 (1.80)	.185	.797	1.78
694	50			−1.037 (1.44)	165.8 (1.19)	78.4 (2.00)	.183	.810	1.78

The estimates of the linear version of the price equation are fairly stable in Table 12–13, although the estimate of the coefficient of the demand pressure variable is larger in absolute value for the periods before 671 than it is for the periods after. As for the nonlinear estimates, it is difficult to tell how stable or unstable they are because of the multicollinearity among the estimates, but the last three sets of estimates appear to be reasonably stable.

It is true, as is examined in Fair [15], that the price equation consistently underpredicts the inflation in 1969 unless it is estimated through 1969. As discussed in Chapter 10, however, this is not necessarily unexpected, since one generally cannot expect an equation to extrapolate well into a period where the values of the dependent and independent variables are considerably different from what they were during the period of estimation. It thus may be too early to tell how stable the nonlinear version of the price equation is. It is true for the work below, however, that the use of the estimates in Table 12–13 to generate outside-sample forecasts results in an underprediction of the rate of inflation in 1969.

Monthly Housing Starts

The results of estimating the demand equation (8.23) for the eighteen sample periods are presented in Table 12–14 and the results of estimating the supply equation (8.24) in Table 12–15. To conserve space, the estimates of the coefficients of the seasonal dummy variables and the working-day variable have not been presented in the tables: the estimates were fairly stable over the different sample periods.

The 1965–1969 period was a difficult period in which to explain housing starts, since it included the crunch in 1966 and the very high interest rates in 1968 and 1969. The results in Table 12–14 and 12–15 reflect the difficulty. Looking at the demand equation in Table 12–14 first, only the estimate of the coefficient of $/\Delta RM_t/$ is at all stable. The estimates of the coefficients of the housing stock variable and the time trend and the estimate of the serial correlation coefficient have all been increasing in absolute value over time, and the estimate of RM_{t-2} has been decreasing in absolute value. Except for a slight drop in early 1967, the mortgage rate has essentially been rising throughout the entire 1965–1969 period, and as the rate has been rising, the estimated negative effect it has on housing demand has been falling.

For the supply equation the results are somewhat better, as can be seen in Table 12–15, although the estimate of the constant term and the estimate of the coefficient of RM_{t-1} have not been stable. The estimate of the coefficient of RM_{t-1} was negative for the periods ending before March 1968

Table 12–14. Coefficient Estimates of Equation (8.23) for Eighteen Sample Periods. (Dependent variable is HS_t.)

End of Sample Period	No. of Observations	Constant	Coefficient Estimates for $\sum_{i=1}^{t-1} HS_i$	t	RM_{t-2}	$\|\Delta RM_t\|$	$\hat{r}$	SE	$R\Delta^2$
Sept. 1965	76	487.04	−.0023	.11	−.725	−.619	.436 (4.23)	8.44	.836
Dec. 1965	79	477.82	−.0018	.08	−.714	−.548	.435 (4.29)	8.28	.838
March 1966	82	444.72	−.0029	.24	−.662	−.423	.413 (4.10)	8.30	.842
June 1966	85	456.89	−.0025	.19	−.680	−.411	.408 (4.11)	8.25	.841
Sept. 1966	88	446.99	−.0037	.34	−.663	−.371	.405 (4.15)	8.12	.842
Dec. 1966	91	396.82	−.0076	.84	−.593	−.462	.407 (4.25)	8.40	.826
March 1967	94	349.05	−.0145	1.69	−.518	−.485	.486 (5.39)	8.45	.822
June 1967	97	340.90	−.0187	2.20	−.505	−.448	.505 (5.76)	8.32	.826
Sept. 1967	100	328.88	−.0300	3.56	−.480	−.391	.557 (6.70)	8.51	.811
Dec. 1967	103	308.88	−.0374	4.46	−.453	−.424	.620 (8.03)	8.55	.813
March 1968	106	281.06	−.0459	5.49	−.402	−.478	.684 (9.65)	8.74	.808
June 1968	109	252.85	−.0525	6.28	−.356	−.334	.714 (10.65)	9.05	.797
Sept. 1968	112	180.17	−.0584	6.99	−.236	−.426	.785 (13.41)	9.11	.787
Dec. 1968	115	164.30	−.0637	7.62	−.207	−.388	.808 (14.69)	9.13	.786
March 1969	118	134.85	−.0740	8.86	−.163	−.411	.846 (17.24)	9.18	.787
June 1969	121	126.44	−.0738	8.83	−.150	−.392	.850 (17.71)	9.06	.791
Sept. 1969	124	101.14 (1.98)	−.0703 (2.16)	8.40 (2.21)	−.107 (1.16)	−.430 (2.92)	.848 (17.82)	9.03	.789
Dec. 1969	127	112.95 (2.46)	−.0709 (2.27)	8.48 (2.31)	−.127 (1.54)	−.412 (2.81)	.841 (17.54)	8.98	.790

Note: t-statistics are not presented for most of the estimates because of the inability to invert the appropriate matrix.

Table 12–15. Coefficient Estimates of Equation (8.24) for Eighteen Sample Periods. (Dependent variable is HS_t.)

End of Sample Period	No. of Observations	Constant	Coefficient Estimates for t	$DHF3_{t-2}$	$DSF6_{t-1}$	RM_{t-1}	$\backslash\Delta RM_t\backslash$	$\hat{r}$	SE	$R\Delta^2$
Sept.	76	12.85	−.189	.0600	.0463	0	−.619	.395	8.88	.819
1965								(3.75)		
Dec.	79	17.43	−.053	.0417	.0365	0	−.548	.455	8.85	.815
1965								(4.54)		
March	82	15.93	−.072	.0473	.0379	0	−.423	.444	8.69	.827
1966								(4.49)		
June	85	11.79	−.139	.0398	.0468	0	−.411	.460	8.64	.826
1966								(4.78)		
Sept.	88	7.77	−.146	.0337	.0483	0	−.371	.479	8.52	.826
1966								(5.11)		
Dec.	91	4.26	−.147	.0318	.0491	0	−.462	.466	8.51	.821
1966								(5.02)		
March	94	5.03	−.145	.0332	.0485	0	−.485	.467	8.39	.825
1967								(5.12)		
June	97	6.95	−.163	.0432	.0475	0	−.448	.470	8.28	.827
1967								(5.24)		
Sept.	100	11.63	−.162	.0434	.0475	0	−.391	.459	8.23	.823
1967								(5.17)		
Dec.	103	9.11	−.164	.0432	.0477	0	−.424	.452	8.14	.830
1967								(5.15)		
March	106	.39	−.149	.0488	.0487	.019	−.478	.463	8.21	.832
1968								(5.37)		
June	109	−9.83	−.149	.0499	.0500	.035	−.334	.452	8.38	.828
1968								(5.30)		
Sept.	112	−44.45	−.164	.0538	.0529	.089	−.426	.470	8.39	.821
1968								(5.64)		
Dec.	115	−65.79	−.172	.0556	.0552	.125	−.388	.505	8.41	.820
1968								(6.28)		
March	118	−74.41	−.176	.0567	.0560	.136	−.441	.506	8.35	.826
1969								(6.38)		
June	121	−60.75	−.166	.0536	.0545	.117	−.392	.511	8.26	.828
1969								(6.55)		
Sept.	124	−54.79	−.168	.0529	.0541	.111	−.430	.508	8.32	.822
1969		(1.88)	(2.69)	(5.39)	(8.04)	(2.85)	(2.92)	(6.57)		
Dec.	127	−49.22	−.164	.0497	.0541	.100	−.412	.507	8.30	.822
1969		(1.75)	(2.63)	(5.27)	(8.07)	(2.67)	(2.81)	(6.64)		

Note: t-statistics are not presented for most of the estimates because of the inability to invert the appropriate matrix.

(although less negative than the corresponding estimate of the coefficient of RM_{t-2} in the demand equation), and for the results presented in Table 12–15 the coefficient was constrained to be zero for these periods. The data before 1968 did not appear to be capable of picking up separate demand and supply effects from the mortage rate. The estimates of the coefficients of the two deposit flow variables have been fairly stable, although they were generally smaller before 1968 than afterwards.

The results in the two tables are thus not too encouraging. Perhaps the most encouraging result is that the estimates have been fairly stable in 1969. The mortgage rate did rise during the 1966–1969 period to levels much higher than ever before observed, however; and on this ground one would not expect the housing starts equations to have performed too well during this period. Whether the equations will prove to be more stable in the future is perhaps still uncertain. The estimates in Tables 12–14 and 12–15 have been used in the work below, and from the results it will be possible to tell how sensitive the forecasting accuracy of the model is to the use of these somewhat unstable estimates.

Conclusion

The question under consideration in this chapter is whether the estimated relationships in the model are stable enough in the short run to allow accurate forecasts to be made. The one conclusion that is evident from the results that have just been presented is that the estimated relationships are not stable enough to lead to the conclusion that the outside-sample forecasts are as accurate as the within-sample forecasts. Just how much accuracy is lost by having to make outside-sample forecasts will be examined in the next section. In general, however, the above results appear to be moderately good. The most unstable equations are the inventory investment equation, the labor force participation equation for secondary workers, the price equation, and the two housing starts equations. The other equations are generally fairly stable.

12.3 Results of Forecasting Outside of the Sample Period

The Quarterly Results

Using the estimates of the model that have just been presented, one-, two-, three-, four-, and five-quarter-ahead forecasts were generated beyond the sample period. For the first set of forecasts, for example, the estimates through

653 were used to forecast 654, 661, 662, 663, and 664. Then for the second set of forecasts, the estimates through 654 were used to forecast 661, 662, 663, 664, and 671; and so on for the seventeen different sets of estimates. The eighteenth set of estimates presented above was not used, since no forecasts were made beyond 694. The eighteenth set of estimates was the one used for the within-sample forecasts in Chapter 11. The outside-sample forecasts can be compared with the within-sample forecasts of Chapter 11 to see how much accuracy has been lost by having to forecast beyond the sample period.

Aside from using different coefficient estimates, the outside-sample forecasts were generated in the same way as the within-sample forecasts in Chapter 11. With respect to the coefficient estimates, only the estimates of the production function parameter α_t in Chapter 9, the interpolations of the two agricultural series in Chapter 10, and the estimates of the HP_t equation in (10.2) remained the same for the outside-sample forecasts. For each set of forecasts, potential GNP was calculated using only the coefficient estimates of the labor force participation equations and the D_t equation that would have been available at the time the forecasts would have been made. As discussed above, this same procedure was followed for the estimates of the price equation in Table 12–13.

In Table 12–16 the mean absolute errors (both in terms of levels and changes) for the within-sample forecasts of Chapter 11 and the outside-sample forecasts of this chapter are presented for 15 endogenous variables. The endogenous variables are the same as those considered previously in Table 11–5. The prediction period was from 654 through 694, so there were 17 one-quarter-ahead forecasts that were generated, 16 two-quarter-ahead forecasts, 15 three-quarter-ahead forecasts, 14 four-quarter-ahead forecasts, and 13 five-quarter-ahead forecasts. The mean absolute errors in Table 12–16 for the within-sample forecasts differ from those in Table 11–5 because of the different prediction periods that were used to compute the error measures. Also, the results in Table 12–16 should not be used to compare the one-quarter-ahead forecasts with the two-quarter-ahead forecasts, and so on, since the prediction periods differ. The results in Table 12–16 are meant to be used only for comparing the within-sample and outside-sample forecasts. At the bottom of Table 12–16 the error measures that have been computed for GNP_t for the eight quarters of 1968 and 1969 are presented.

Comparing the one-quarter-ahead forecasts in Table 12–16, the results are fairly close, with the difference between the mean absolute errors of the GNP forecast being only .16 billion dollars. For the two-quarter-ahead forecast of GNP the difference is .56 for the error in terms of levels and .76 for the error in terms of changes; for the three-quarter-ahead forecast the difference is 1.38 in terms of levels and .16 in terms of changes; for the four-quarter-ahead forecast the difference is 1.94 in terms of levels and .09 in terms of changes; and for the five-quarter-ahead forecast the difference is 3.19 in terms of levels and .25 in terms of changes. For the three-, four-, and five-quarter-ahead forecasts there is thus a tendency for the outside-sample forecasts to be much worse (relative to the within-sample forecasts) for the predictions in terms of levels than for the predictions in terms of changes. This conclusion also holds in general for the other endogenous variables of the model.

For all of the variables except the price deflator the errors in terms of changes for the outside-sample forecasts are quite close to the errors in terms of changes for the within-sample forecasts. In terms of forecasting the change in the variables, little accuracy appears to have been lost in making outside-sample forecasts. It was mentioned in Chapter 11 that in judging the accuracy of the forecasts the mean absolute error in terms of changes is probably a more useful measure than the error in terms of levels, and it is encouraging that for this error measure the outside-sample forecast errors in Table 12–16 are so close to the within-sample errors.

It should be noted from the results presented at the bottom of Table 12–16 that for the 1968–1969 period the within-sample and outside-sample results are quite close using either error measure. For this period little accuracy appears to have been lost in making outside-sample forecasts, either in terms of forecasting changes or in terms of forecasting levels.

In order to compare the accuracy of the outside-sample forecasts to changes in the forecast horizon, the mean absolute errors for the one-through four-quarter-ahead forecasts were computed for the same prediction period that was used for the five-quarter-ahead forecasts (664–694, 13 observations). The results are presented in Table 12–17. Also, the outside-sample results for the 1968–1969 period presented at the bottom of Table 12–16 are presented again at the bottom of Table 12–17.

There is definitely a tendency for the errors in terms of levels in Table 12–17 to compound as the forecast horizon lengthens. The MAE for GNP, for example, increases from 2.50 billion dollars for the one-quarter-ahead forecast to 6.98 billion dollars for the five-quarter-ahead forecast. Again, this is not true for the 1968–1969 period, however, where the MAE for GNP only increases from 2.61 to 2.88 billion dollars. Also, there is little tendency for the errors in terms of changes to compound as the forecast horizons lengthen. Indeed, for some of the variables the errors actually drop slightly as the horizon lengthens. Only for the price deflator is there much evidence that the errors in terms of changes are compounding. The worst results in Table 12–17 are those for the secondary labor force (LF_{2t}). The MAE for

Table 12–16. Comparisons of the Within-Sample and Outside-Sample Forecasts.

Variable	One quarter ahead (17 observations)		Two quarters ahead (16 observations)		Three quarters ahead (15 observations)		Four quarters ahead (14 observations)		Five quarters ahead (13 observations)	
	Within-Sample	Outside-Sample	Within-Sample	Outside-Sample	Within-Sample	Outside-Sample	Within-Sample	Outside-Sample	Within-Sample	Outside-Sample
MAE										
GNP_t	2.31	2.47	3.38	3.94	2.50	3.88	2.73	4.67	3.79	6.98
CD_t	1.33	1.46	1.43	1.90	1.29	1.77	1.31	2.41	1.35	2.62
CN_t	1.29	1.62	1.42	2.15	1.46	2.48	1.35	1.77	1.25	3.39
CS_t	.37	.43	.51	.75	.70	1.13	.80	1.59	.85	1.98
IP_t	1.10	1.36	1.15	1.54	1.19	1.75	1.38	2.17	1.47	2.50
IH_t	.73	.82	1.14	1.62	1.27	2.36	1.36	3.05	1.39	3.86
$V_t - V_{t-1}$	2.37	3.13	3.16	3.78	3.18	3.92	2.95	3.64	2.86	3.66
IMP_t	.64	.73	.91	1.20	1.14	1.66	1.06	1.78	.89	1.61
PD_t	.16	.17	.29	.30	.40	.45	.45	.67	.45	.89
$GNPR_t$	2.23	2.61	3.10	4.11	2.59	4.05	2.60	4.06	2.63	5.14
M_t	123	136	201	184	259	253	325	298	345	374
D_t	157	188	162	228	143	204	157	256	139	245
LF_{1t}	46	52	53	61	54	63	55	65	59	73
LF_{2t}	193	283	269	438	260	588	268	735	262	847
UR_t	.0016	.0031	.0028	.0055	.0033	.0071	.0037	.0083	.0042	.0094

MAEΔ										
GNP_t			2.22	2.98	3.02	3.18	2.84	2.93	2.49	2.74
CD_t			1.50	1.51	1.58	1.57	1.29	1.37	1.34	1.45
CN_t			1.32	1.47	1.36	1.45	1.48	1.66	1.62	1.89
CS_t			.39	.46	.38	.49	.36	.47	.37	.48
IP_t	s		1.03	1.25	1.18	1.32	1.13	1.32	1.29	1.39
IH_t	a		.89	1.01	1.01	1.13	.97	1.11	1.02	1.27
$V_t - V_{t-1}$	m		4.25	4.39	4.62	4.83	4.76	4.87	4.59	4.66
IMP_t	e		.56	.66	.59	.71	.64	.80	.64	.72
PD_t			.16	.18	.15	.20	.13	.24	.15	.29
$GNPR_t$			2.08	2.86	2.66	2.47	2.22	2.31	1.89	1.92
M_t			166	102	127	120	129	154	131	161
D_t			152	171	169	175	156	170	175	175
LF_{1t}			50	51	52	53	55	56	56	57
LF_{2t}			194	233	195	241	209	236	215	230
UR_t			.0015	.0026	.0013	.0020	.0010	.0015	.0010	.0014

1968–1969 Period Only (8 observations)

MAE for GNP	2.19	2.61	2.67	3.20	2.17	2.71	2.25	2.12	2.73	2.88
MAEΔ for GNP_t	2.19	2.61	1.50	2.23	2.03	1.82	1.77	1.75	1.64	1.47

Table 12–17. Outside-Sample Errors 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 observations
MAE						
GNP_t	2.50	3.70	3.58	4.96	6.98	13
CD_t	1.35	1.78	1.63	2.49	2.62	13
CN_t	1.76	2.23	2.25	2.73	3.39	13
CS_t	.43	.68	1.04	1.57	1.98	13
IP_t	1.46	1.56	1.83	2.30	2.50	13
IH_t	.96	1.78	2.56	3.19	3.86	13
$V_t - V_{t-1}$	3.39	3.80	3.77	3.66	3.66	13
IMP_t	.71	1.19	1.61	1.65	1.61	9
PD_t	.17	.32	.49	.69	.89	13
$GNPR_t$	2.47	3.73	3.74	4.24	5.14	13
M_t	121	182	253	310	374	13
D_t	178	204	161	222	245	13
LF_{1t}	62	69	70	69	73	13
LF_{2t}	291	454	597	730	847	13
UR_t	.0024	.0041	.0057	.0076	.0094	13

MAEΔ						
GNP_t	2.50	3.01	3.07	2.74	2.74	13
CD_t	1.35	1.39	1.37	1.34	1.45	13
CN_t	1.76	1.57	1.63	1.76	1.89	13
CS_t	.43	.41	.43	.45	.48	13
IP_t	1.46	1.36	1.42	1.39	1.39	13
IH_t	.96	1.13	1.20	1.18	1.27	13
$V_t - V_{t-1}$	3.39	4.61	4.89	4.93	4.66	13
IMP_t	.71	.65	.68	.75	.72	9
PD_t	.17	.20	.21	.25	.29	13
$GNPR_t$	2.47	2.89	2.31	2.18	1.92	13
M_t	121	89	137	158	161	13
D_t	178	183	178	175	175	13
LF_{1t}	62	56	57	57	57	13
LF_{2t}	291	246	239	230	230	13
UR_t	.0024	.0019	.0015	.0013	.0014	13
1968–1969 Period Only						
MAE for GNP_t	2.61	3.20	2.71	2.12	2.88	8
MAEΔ for GNP_t	2.61	2.23	1.82	1.75	1.47	8

LF_{2t} increases from 291 thousand for the one-quarter-ahead forecast to 847 thousand for the five-quarter-ahead forecast. This then causes the MAE for the unemployment rate to increase substantially as the forecast horizon lengthens.

The quarter-by-quarter results of the outside-sample forecasts are presented in Table 12–18 for eleven variables. The eleven variables are the same as those considered in Table 11–6 for the within-sample forecasts: 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, $LF_{1t} + LF_{2t}$, and UR_t. As in Table 11–6, the first line for each quarter gives the actual change in each of the variables for that quarter, and the next five lines give, respectively, the one- through five-quarter-ahead forecast of the change in each of the variables for that quarter. The prediction period began in 654, so there was only one forecast generated for 654. Similarly, only two forecasts could be generated for 661, only three for 662, and only four for 663.

Looking at the GNP_t forecasts in Table 12–18 first, the largest errors occurred for 671, where the errors ranged from 5.03 to 13.72 billion dollars. Again, this was due primarily to the failure of the model to forecast the 10.9 billion dollar drop in inventory investment in 671. The model is just not capable, aside from perhaps the one-quarter-ahead forecast, of accounting for the slowdown in 671. The other quarters were forecast much better, and there do not appear to be any other GNP forecasts that would be considered to be highly misleading. Looking at errors of larger than 5 billion dollars, the forecast for 654 was about 5 billion dollars too low, the last three forecasts for 663 were about 5 billion dollars too high, the three-quarter-ahead forecast for 673 was about 5 billion dollars too low, and the last two forecasts for 682 were about 5 billion dollars too low.

With respect to the forecasts of the price deflator in Table 12–18, the (relatively) small increase in the deflator in 671 and 672 was substantially overpredicted (due in large part of the overprediction of GNP in 671) and the large increases in 1969 were somewhat underpredicted, but otherwise the forecasts were fairly good. As discussed in the previous section, the underprediction of the rate of inflation in 1969 was not unexpected.

The employment forecasts in Table 12–18 appear to be reasonable, but the unemployment rate forecasts are not. The labor force was consistently underpredicted throughout most of the period, and the compounding of the errors in predicting the level of the labor force led to substantial underprediction of the unemployment rate. Only in 1969 could the unemployment rate prediction more than one quarter ahead be considered to be at all reasonable. Notice from the results in Table 12–17, however, that the errors in predicting the change in the unemployment rate are quite small and do not compound as the forecast horizon lengthens. The failure of the model to

Table 12–18. Actual and Forecasted Changes for Selected Variables of the Model. (Forecasts are outside-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
654		18.90	11.10	3.80	.20	.60	1.50	.34	14.10	731	358	.0411
	1	13.71	8.32	1.81	.13	−.55	.70	.74	7.25	536	129	.0378
661		19.50	10.30	2.60	.0	1.60	1.50	.78	12.05	584	345	.0386
	1	19.12	8.73	3.75	.20	.99	.96	.79	12.08	777	216	.0326
	2	17.85	8.93	3.64	−.31	.10	.91	.83	10.72	717	263	.0309
662		13.80	4.10	1.50	−1.50	4.90	1.10	1.07	5.90	603	507	.0383
	1	15.46	8.71	2.45	−.40	−.26	.83	.87	8.45	596	232	.0309
	2	15.92	9.79	2.44	−.54	−.88	.80	.90	8.73	867	328	.0242
	3	16.16	8.74	2.46	−.25	.13	.83	.93	8.81	617	308	.0245
663		12.60	9.30	2.70	−1.20	−4.30	2.20	.88	5.20	656	576	.0377
	1	10.26	7.78	2.79	−1.25	−6.59	.57	.96	2.73	316	145	.0334
	2	17.34	9.27	3.12	−1.05	−1.27	.93	.99	8.85	727	310	.0252
	3	18.00	8.96	3.16	−1.21	−.20	.90	1.01	9.30	662	317	.0193
	4	17.97	8.74	3.12	−.95	−.23	.92	1.04	9.18	561	305	.0204
664		14.80	3.40	1.20	−2.70	8.00	.60	.88	7.90	290	688	.0369
		10.84	7.01	2.15	−2.07	−1.06	.68	1.02	3.63	342	217	.0316
	2	11.12	7.21	2.16	−2.12	−1.21	.62	1.06	3.70	342	304	.0286
	3	12.77	8.14	2.21	−1.81	−.78	.69	1.11	4.79	417	351	.0207
	4	13.33	8.67	2.24	−1.71	−.90	.67	1.14	5.13	421	353	.0149
	5	12.43	7.81	2.17	−1.94	−.66	.64	1.15	4.33	334	335	.0165

Table 12–18 (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
671		3.50	6.60	−.90	−.60	−10.90	.50	.60	−1.60	258	358	.0376
	1	8.53	5.96	.58	−.37	−7.22	.52	1.07	.31	115	70	.0333
	2	13.88	7.21	.75	−1.13	−2.19	.87	1.11	4.83	412	257	.0278
	3	16.06	8.06	.85	−1.28	−.78	.89	1.15	6.55	261	282	.0264
	4	16.81	9.01	.83	−1.35	−.88	.90	1.22	6.71	313	304	.0186
	5	17.22	9.10	.85	−1.37	−.60	.86	1.25	6.90	330	306	.0127
672		9.30	8.60	−.30	1.60	−5.60	−.30	.57	4.00	32	171	.0386
	1	8.95	5.09	−.05	2.09	−2.22	.55	.99	1.47	−4	6	.0356
	2	7.78	5.44	−.32	1.80	−2.96	.47	1.14	−.34	−6	125	.0332
	3	12.52	8.23	−.20	1.70	−.72	.78	1.19	3.48	191	228	.0273
	4	14.83	9.29	−.10	1.71	.46	.82	1.24	5.24	225	264	.0262
	5	14.40	9.68	−.19	1.19	.20	.77	1.33	4.27	240	273	.0186
673		16.90	6.00	.50	3.40	4.40	.60	1.12	7.50	186	752	.0386
	1	17.45	8.87	1.68	1.80	2.84	1.02	1.01	8.56	290	272	.0353
	2	12.97	8.86	1.37	1.75	−1.63	.79	1.03	4.58	161	287	.0338
	3	11.32	7.93	1.17	1.95	−2.44	.69	1.18	2.35	−11	291	.0331
	4	16.45	9.80	1.41	2.10	.77	1.03	1.25	6.31	211	367	.0263
	5	18.31	10.82	1.51	2.11	1.48	1.01	1.31	7.59	286	389	.0250
674		15.70	6.90	1.50	2.40	1.70	2.10	1.05	5.50	453	571	.0392
	1	14.00	9.99	1.03	.52	−2.24	.80	1.04	4.06	226	218	.0369
	2	17.47	9.36	1.13	.73	1.88	1.03	1.05	7.04	379	330	.0329
	3	17.67	9.26	1.13	.53	2.42	1.08	1.05	7.20	268	335	.0325
	4	14.83	8.80	.84	.25	.43	.90	1.19	4.01	88	315	.0332
	5	16.98	10.04	.89	.26	1.45	1.06	1.30	5.21	236	361	.0257

681		19.20	18.10	4.10	−.30	−7.90	3.10	.98	9.80	434	106	.0369
	1	20.28	11.27	3.10	−.11	−.81	1.27	1.05	10.33	426	243	.0362
	2	23.11	10.22	3.30	−.22	3.22	1.31	1.06	12.70	476	278	.0338
	3	21.02	9.79	3.12	.02	1.42	1.23	1.07	10.86	458	342	.0302
	4	21.28	10.02	3.13	−.20	1.73	1.30	1.06	11.10	423	352	.0303
	5	19.44	9.42	3.01	−.70	1.00	1.18	1.19	8.85	253	326	.0321
682		23.40	9.60	−2.70	1.70	8.30	1.40	1.15	12.50	533	508	.0360
	1	26.65	7.84	1.10	.17	11.64	2.00	1.07	15.70	690	316	.0328
	2	19.68	10.07	.82	−.98	2.90	1.24	1.06	9.81	598	285	.0331
	3	19.30	10.32	.82	−.58	1.74	1.10	1.08	9.40	537	306	.0314
	4	18.21	9.76	.68	−.27	1.00	1.07	1.08	8.42	477	341	.0284
	5	18.11	9.39	.67	−.41	1.46	1.11	1.07	8.43	442	344	.0289
683		17.70	14.60	1.70	−.30	−2.70	2.40	1.03	7.00	253	146	.0356
	1	18.37	10.48	3.22	−1.12	.34	1.34	1.09	7.26	461	283	.0349
	2	15.25	11.24	2.18	−1.07	−2.76	1.14	1.09	4.60	562	316	.0312
	3	18.19	10.55	2.45	−.87	.41	1.14	1.08	7.15	412	268	.0326
	4	19.34	10.60	2.53	−.35	.87	1.10	1.10	8.00	427	298	.0311
	5	18.28	10.16	2.44	−.45	.41	1.07	1.11	7.07	383	321	.0286
684		16.10	5.80	3.40	2.00	3.30	1.30*	1.20	5.70	399	226	.0340
	1	18.92	9.32	.89	−.04	5.13	1.47	1.09	8.62	391	325	.0349
	2	13.26	8.78	.55	−1.40	1.21	.97	1.09	3.94	405	280	.0338
	3	13.07	8.33	.16	−1.28	1.74	.98	1.09	3.75	248	275	.0312
	4	13.24	9.29	.26	−.87	.30	.83	1.08	3.98	261	264	.0325
	5	13.62	9.50	30	−1.04	.54	.77	1.10	4.16	301	292	.0311
691		16.20	11.30	3.80	1.40	−3.90	1.40*	1.40	4.60	733	959	.0336
	1	20.63	12.26	5.72	−.29	−2.25	1.61	1.13	9.73	423	378	.0330
	2	18.86	10.69	6.11	−.38	−.69	1.46	1.13	8.28	486	336	.0330
	3	18.15	10.29	6.12	−.65	−.88	1.33	1.11	7.80	321	288	.0327
	4	16.69	10.24	5.32	−.32	−1.90	1.25	1.12	6.59	254	297	.0308
	5	17.50	10.13	5.33	−.64	−.83	1.10	1.10	7.35	265	288	.0320

Table 12–18 (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
692		16.10	10.80	2.50	−.60	.30	1.40*	1.55	3.60	439	280	.0349
	1	19.12	10.69	1.23	−.16	3.15	1.48	1.23	7.78	405	246	.0321
	2	16.01	10.04	.63	−.42	3.11	1.25	1.16	5.55	432	376	.0316
	3	14.04	10.03	.81	−.15	.55	1.09	1.16	3.97	288	330	.0323
	4	14.88	10.10	.79	.66	.53	1.09	1.14	4.81	258	318	.0322
	5	14.41	9.72	.67	.60	.59	1.08	1.14	4.43	212	325	.0306
693		18.00	7.00	3.30	−1.30	3.80	1.40*	1.41	3.90	334	688	.0363
	1	20.75	11.87	2.94	−1.17	2.32	1.61	1.33	6.56	274	247	.0369
	2	18.29	11.29	3.17	−1.12	1.16	1.42	1.25	4.95	443	206	.0332
	3	17.41	11.39	2.94	−.73	−.03	1.36	1.19	4.58	234	241	.0340
	4	17.77	11.07	3.18	.16	−.47	1.38	1.18	4.90	207	228	.0348
	5	17.97	10.81	3.18	.06	.04	1.32	1.16	5.25	198	223	.0347
694		9.40	9.60	1.40	.10	−3.00	.70	1.36	−.80	210	417	.0359
	1	6.58	8.62	−.82	−.73	−1.89	.51	1.31	−2.76	−17	148	.0398
	2	11.26	8.53	−.43	−.88	2.81	.87	1.32	.86	241	244	.0374
	3	9.92	8.28	−.27	−1.04	1.62	.77	1.26	.12	101	207	.0349
	4	9.72	8.16	−.51	−.48	1.21	.76	1.19	.26	87	257	.0360
	5	9.22	8.09	−.42	−.74	.90	.72	1.19	−.10	86	254	.0367

* Adjusted value rather than the actual value.

forecast the level of the unemployment rate with any degree of accuracy is due to the failure to account for the large growth of the secondary labor force in the last half of the 1960s. To the extent that the equation explaining the labor force participation of secondary workers continues to perform poorly in the future, the forecasts of the level of the unemployment rate will continue to be poor.

It can be seen from the results in Table 12–18 why in Table 12–17 the mean absolute errors in terms of levels for GNP are so much smaller for the 1968–1969 period than they are for the entire period. The errors that were made in 671 were carried forward in terms of levels into the rest of 1967, which contributed substantially to the size of the overall error measure in terms of levels for the four- and five-quarter-ahead forecasts. No such compounding problem occured in 1968 and 1969, and thus the size of the error measure in terms of levels for the four- and five-quarter-ahead forecasts was much smaller for this period.

Results from the Monthly Housing Starts Equation

In order to compare the within-sample forecasts of HSQ_t with the outside-sample forecasts, the mean absolute errors (both in terms of levels and changes) of the forecasts of HSQ_t in Chapter 11 and of the forecasts of HSQ_t in this chapter were computed for the same prediction period. The results are presented in Table 12–19. As was the case for the results in Table 11–7, the errors in Table 12–19 are in thousands of units at annual rates. Table 12–19 is similar to Table 12–16 in that the results in the table are meant to be used only for comparing the within-sample and outside-sample forecasts.

Comparing the one-quarter-ahead forecasts in Table 12–19, the difference between the mean absolute errors is 26.3 thousand units (at annual rates). For the level errors for the two- through five-quarter-ahead forecasts the differences are respectively, 63.2, 93.4, 125.4, and 200.6 thousand units. For the change errors the differences are respectively, 40.3, 45.0, 52.4, and 67.4 thousand units. As was the case for the results in Table 12–16, the differences are smaller for the errors in terms of changes than for the errors in terms of levels. For the three-, four-, and five-quarter-ahead forecasts the differences for the errors in terms of levels are quite large.

In order to compare how the accuracy of the outside-sample forecasts of HSQ_t varies with the length of the forecast horizon, the mean absolute errors for the one- through four-quarter-ahead forecasts were computed

Table 12–19. Comparison of the Within-Sample and Outside-Sample Forecasts of HSQ_t. (Errors are in thousands of units at annual rates.)

Error Measure	One Quarter Ahead (17 observations) Within-sample	One Quarter Ahead (17 observations) Outside-sample	Two Quarters Ahead (16 observations) Within-sample	Two Quarters Ahead (16 observations) Outside-sample	Three Quarters Ahead (15 observations) Within-sample	Three Quarters Ahead (15 observations) Outside-sample	Four Quarters Ahead (14 observations) Within-sample	Four Quarters Ahead (14 observations) Outside-sample	Five Quarters Ahead (13 observations) Within-sample	Five Quarters Ahead (13 observations) Outside-sample
MAE	58.3	84.6	74.8	138.0	79.6	173.0	82.9	208.3	77.8	278.4
MAEΔ	58.3	84.6	47.8	88.1	53.8	98.8	57.0	109.4	53.3	120.7

for the same period (13 observations) that was used in Table 12–19 for the five-quarter-ahead forecasts. The results are presented in Table 12–20. There is definitely a tendency for the errors in terms of levels to compound as the forecast horizon increases, but only a very slight tendency for the errors in terms of changes. For the errors in terms of levels the five-quarter-ahead forecast error is about three times as large as the one-quarter-ahead error.

Table 12–20. Outside-Sample Forecast Errors of HSQ_t Computed for the Same Prediction Period. (Errors are in thousands of units at annual rates.)

	Length of Forecast					
Error Measure	One Quarter Ahead	Two Quarters Ahead	Three Quarters Ahead	Four Quarters Ahead	Five Quarters Ahead	No. of Observations
MAE	98.5	155.0	192.0	222.5	278.4	13
MAEΔ	98.5	103.0	104.6	114.1	120.7	13

In Table 12–21 the quarter by quarter results of the outside-sample forecasts of HSQ_t are presented for the 654–694 period. As in Table 11–8, the forecasts of HSQ_t in Table 12–21 are at annual rates, since this is the form in which the housing starts series is most widely followed. It is quite evident from the results in Table 12–21 that the model has consistently underpredicted the level of housing starts. This is contrary to the case for the within-sample forecasts in Table 11–8, where no such tendency was observed. The reason for this underprediction is clear from the estimates of the demand equation in Table 12–14. As the mortgage rate rose throughout the 1965–1969 period, the negative influence that it had on housing starts in the demand equation fell. Therefore, when the demand equation was used to forecast housing starts beyond the sample period, using the actual values of the mortgage rate, the equation tended to underpredict the level of housing starts. In other words, the equation was extrapolated into the future using values of the mortgage rate that were consistently larger than had been observed during the period of estimation. One generally cannot expect an equation to perform well under these circumstances, and the present case is no exception. Whether the demand equation will perform better in the future is not clear, but at least the strong (and misleading) negative effect that the mortgage rate had in the demand equation no longer exists.

It is now clear why there was so much compounding of the level errors of HSQ_t in Table 12–20, and why the outside-sample forecast errors in Table 12–19 were so much larger than the within-sample errors. The under-prediction of the level of housing starts became larger and larger as the forecast horizon lengthened.

Table 12–21. Actual and Forecasted Levels of HSQ_t. (Forecasts are outside-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
654	1463	1377				
661	1349	1359	1268			
662	1267	1303	1280	1243		
663	1018	1043	1116	1095	1042	
663	883	858	846	910	889	788
671	1038	891	790	772	881	786
672	1206	1220	1174	1132	1112	1112
673	1316	1228	1249	1201	1156	1136
674	1420	1318	1239	1239	1172	1115
681	1436	1256	1214	1160	1141	1038
682	1434	1350	1236	1212	1173	1152
683	1449	1292	1214	1140	1104	1045
684	1548	1401	1201	1143	1068	1009
691	1604	1456	1346	1200	1136	1031
692	1507	1533	1455	1402	1289	1234
693	1341	1376	1402	1348	1294	1153
694	1290	1417	1371	1396	1335	1254

Conclusion

In conclusion, in terms of predicting the changes in the variables, the outside-sample forecasts were nearly as good as the within-sample forecasts. The two exceptions to this were the forecast of the change in the price deflator and the forecast of the change in housing starts. In terms of predicting the levels of the variables, the outside-sample forecasts were in general not as good, although much of this was due to the larger errors made in 671 by the outside-sample forecasts. The forecasts for 671 were clearly misleading, as they were for the within-sample forecasts as well, but few of the other forecasts in terms of changes could be considered to be poor. In terms of levels, the size of the labor force and the level of housing starts were consistently under-predicted.

The result in this chapter are thus encouraging. The relationships in the model do appear to be stable enough over time to allow accurate outside-sample forecasts to be made. The major questions for the future are how stable the price equation, the labor force participation equation for secondary workers, and the demand equation for housing starts will prove to be.