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Further Evidence on the Value of a Priori Information

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IN A 1976 PAPER in this Journal, William Brainard and I reported the results of applying a mixed estimation procedure to the asset demand equations of savings and loan associations and mutual savings banks. In each sector, the least squares estimates were both implausible and receptive to a priori information. Even with the simplifying assumptions of normality and exchangeability, the incorporation of prior information through a mixed estimation technique yielded estimates which predicted reasonable asset responses to a wide variety of experiments.

Actual root mean square errors for one to eight quarter ahead predictions were also calculated within and outside the sample period used for estimation. For savings and loans, the least squares estimates, mixed estimates and even our pure priors (using prior means for all parameters other than the intercept) forecast out of sample about equally well. Although their overall records were roughly comparable, there were some differences in forecasting particular variables a specific number of quarters ahead. Surprisingly often, one method would forecast better than another method one quarter ahead but not as well as eight quarters ahead.

For mutual savings banks, the pure priors outforecast the pure data for five of the six assets in the one quarter ahead tests and were roughly comparable to least squares in the farther ahead tests. The mixed predictions were more accurate than least squares in every case but one, short term bonds one quarter ahead. For both sectors, naive autoregressive forecasts had an impressive accuracy one quarter ahead that declined dramatically as the forecasting period lengthened.

A number of developments may now have made these results obsolete. The Federal Reserve Board's flow of funds data have been revised and, with the passage of time, there are now more data available. In addition, the orthogonalization routine in the computer program that we used has been changed. Computational accuracy has been a continuing concern because of the need to invert fairly large moment matrices for highly intercorrelated variables. In the Kim Peck version of TSP which we originally used there were two orthogonalization options. The routine we utilized was advertised as providing "extra precision," and did seem to give more stable estimates during a variety of tests we conducted involving transformations of the data base. These two program options have now been replaced by a presumably even more accurate algorithm.

In the present paper I have reestimated the asset demand equations using the current TSP orthogonalization routine and the revised and enlarged data base. The prior probability distributions are identical to those used in the earlier paper.

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The additional data provides fresh evidence and the revised data, since it is presumably better, supplies more accurate evidence. Of course no specific data can "prove" the superiority of our approach. The results of any test might be simply due to chance events or measurement errors in a particular historical period. The acceptance of our approach must ultimately rely upon judgmental assessments of an accumulation of evidence. This paper provides additional information.

Overall the results support our thesis even more strongly. Some of this evidence is direct. The mixed estimates have not changed much but do seem even more reasonable than in the earlier paper. There is also strong indirect evidence provided by the volatility of the least squares estimates. These estimates have changed substantially while remaining implausible. In the earlier paper, we emphasized the implausibility of the estimates based solely on highly intercorrelated data. Now in addition their instability is a strong indictment of the reliability of least squares estimates, for it is difficult to take seriously parameter estimates that are so sensitive to data revisions. There has also been an interesting change in the accuracy of the models' predictions. In the out of sample forecasting tests, the mixed estimates are relatively more successful and the pure priors less so. This brings out more clearly than before the attractive moral that data and priors together are better than either alone.

Savings and Loan Associations

The four S&L asset categories are currency plus demand deposits, short term bonds, long term bonds, and equity. The original sample periods were 1952.I through 1969.IV in-sample and 1970.I through 1972.IV out-of-sample. Using the revised data I reestimated the model for the period 1952.I through 1972.IV, and then used 1973.I–1976.IV for out-of-sample.

The estimated short run coefficients are contained in Tables I and II. As in the earlier paper, the least squares estimates are pretty wild. However, the patterns of implausibility have shifted considerably. Consider for instance a $1 billion dollar increase in anticipated wealth, accompanied by an equal increase in desired holdings of currency plus demand deposits. The original least squares estimates predicted in billions of dollars, a 1.277 increase in currency plus demand deposits, a .192 increase in shorts, a .356 decline in longs and a .112 decline in mortgages. With the revised least squares estimates there is only a .447 increase in currency plus demand deposits, a .130 decline in shorts, a .073 decline in longs, a .756 increase in mortgages. Neither set of estimates is plausible and their instability is an indictment of their credibility. Interestingly, the one exception to this characterization of least squares is the unanticipated deposit inflow column ($S - S^e$), which continues to be reasonable.

The OLS adjustment process is generally not only unlikely but very slow, though stable. For the previous example, after five years predicted mortgage holdings are still $.21 billion below desired. In the case of a $1 billion increase in wealth and desired short term bonds, mortgages initially drop by $1.01 billion and after ten years still remain $.125 billion below desired holdings.

The mixed estimates in contrast are little affected by the revisions. The small changes which have occurred seem to be improvements. (The posterior means

Table I

Savings and Loan Associations Short-Run Coefficients

		Rate Responses				Adjustment Coefficients					
		1	$\frac{1}{r_S}$	$\frac{1}{r_L}$	$\frac{1}{r_M}$	$\frac{\varphi CDD}{W^E}$	$\frac{\varphi\text{Short}}{W^E}$	$\frac{\varphi\text{Long}}{W^E}$	$\frac{\varphi\text{Mort}}{W^E}$	$\frac{S - S^E}{W^E}$	$\frac{\Delta FHLB}{W^E}$
$\frac{\Delta C + DD}{W^E}$	priors	none	.021	.064	−.072	1.0	.0	.1	.2	.3	.1
	OLS	−.228	−.004	.090	.089	.447	−.176	−.453	−.199	.166	.257
	mixed	.028	−.005	.127	.095	.976	−.014	.083	.050	.177	.210
$\frac{\Delta\text{Short}}{W^E}$	priors	none	−.028	.058	−.074	.0	1.0	.2	.3	.4	.1
	OLS	.033	.001	−.064	.096	−.130	.198	.068	.035	.020	−.084
	mixed	.220	−.008	−.043	−.001	−.005	.980	.203	.209	.060	.023
$\frac{\Delta\text{Long}}{W^E}$	priors	none	.007	−.322	.546	.0	.0	.7	.0	.0	.0
	OLS	.149	.001	.012	−.103	−.073	−.030	.328	.131	.250	−.012
	mixed	.239	.007	−.081	.118	.013	.015	.706	.224	.156	−.033
$\frac{\Delta\text{Mort}}{W^E}$	priors	none	.0	.200	−.400	.0	.0	.0	.5	.3	.8
	OLS	1.046	.004	−.039	−.082	.756	1.008	1.056	1.033	.563	.839
	mixed	.514	.007	−.004	−.210	.017	.020	.009	.519	.607	.800

$\Delta X = X - X_{-1}$.
$\varphi X = X^* - X_{-1}$.

Table II

Savings and Loan Associations Long Run Coefficients

$\frac{\alpha^*}{W^E}$	$\frac{(\bar{\alpha})}{W}$		1.0	$1/r_S$	$1/r_L$	$1/r_M$
$\frac{C+DD^*}{W^E}$	.03	priors	none	.02	.03	.01
		OLS	−.043	−.016	.165	.262
		mixed	−.023	−.007	.140	.094
$\frac{\text{Short}^*}{W^E}$	.02	priors	none	−.03	.03	.01
		OLS	−.054	−.007	−.232	.776
		mixed	.009	−.012	−.017	.026
$\frac{\text{Long}^*}{W^E}$	.06	priors	none	.01	−.46	.78
		OLS	.002	−.025	.045	.381
		mixed	.025	.005	−.114	.296
$\frac{\text{Mort}^*}{W^E}$	.89	priors	none	.00	.40	−.80
		OLS	1.094	.048	.021	−1.419
		mixed	.990	.014	−.010	−.414

can be "unreasonable" because of our reliance upon exchangeability and normality assumptions which give only a rough approximation to our prior beliefs; measurement errors may also distort the posterior distribution.)

The in-sample forecasting results are similar to those in our earlier paper and are not detailed here. Weighting the squared errors in billions of dollars for each asset equally, the mixed RMSE's one period ahead are almost twice as large as OLS and the prior RMSE's are four times as large as OLS. Two eight quarter autoregressive naive models were again estimated. In the first (*N*1), the model was estimated so as to minimize RMSE one quarter ahead. In the second (*N*2), a sequence of five models was estimated so as to minimize RMSE 1, 2, 4, 6, and 8 quarters ahead. Even within sample the naive models have trouble looking very far into the future.

As shown in Table III, the naive models are even less impressive out of sample. The least squares estimated structural model has the lowest overall RMSE 1, 2, and 4 quarters ahead. The mixed estimates are superior 6 and 8 quarters ahead. This supports our belief that least squares relies very heavily on the persistence of the within sample intercorrelations among the explanatory variables. In farther ahead forecasts, these intercorrelations are less likely to continue and the weaknesses of using estimates based solely on the data are more likely to be exposed.

One important difference from the earlier paper is that the forecasts with the pure priors are not very successful. The earlier success of the priors may have conveyed the impression that they were mainly if not solely responsible for the good performance of the mixed model. (This inference might have been precluded by the observation that while the overall records of the mixed and priors were comparable, they did not do equally well in forecasting particular varibles a specific number of quarters ahead.) In the present results it is clear that a good deal of forecasting accuracy may be gained by combining the priors with the data.

Table III

S & L's *RMSE*'s for Out of Sample Forecasts (1973.1–1976.IV)

		Number of Quarters Ahead				
Variable	Method	1	2	4	6	8
	Priors	2.457	3.104	3.694	4.067	4.439
	OLS	.701	.803	.821	.911	.957
$C + DD$	mixed	.732	.821	.724	.737	.740
	*N*1	.566	.745	.719	.969	1.030
	*N*2	.566	.715	.628	.815	.789
	Priors	.745	1.406	2.052	2.308	2.516
	OLS	.522	.713	1.137	1.355	1.454
Short	mixed	1.675	2.123	2.283	2.317	2.214
	*N*1	.536	.830	1.350	1.799	2.106
	*N*2	.536	.778	1.305	1.662	1.849
	Priors	1.670	2.096	2.223	2.175	1.899
	OLS	.681	.868	1.449	1.938	2.098
Long	mixed	1.442	1.799	1.965	2.044	2.176
	*N*1	1.179	1.760	2.647	3.315	3.629
	*N*2	1.179	1.463	2.580	2.949	3.310
	Priors	3.874	5.741	7.092	7.625	7.974
	OLS	.993	1.623	2.803	3.687	4.062
Mort	mixed	1.146	1.531	1.364	1.307	1.030
	*N*1	1.342	3.473	7.934	15.583	22.191
	*N*2	1.342	3.378	7.162	12.525	13.087
$(\sum RMSE^2/4)^{.5}$	Priors	2.469	3.499	4.275	4.603	4.828
	OLS	.744	1.065	1.450	2.237	2.446
	mixed	1.298	1.640	1.692	2.157	1.677
	*N*1	.974	2.025	4.251	8.031	11.304
	*N*2	.974	1.915	3.875	6.500	6.824

Mutual Savings Banks

There are six MSB asset categories: currency plus demand deposits, time deposits, short term bonds, long term bonds, business loans, and equity. Besides the asset data revisions, the time deposit rate series from the MPS data bank has been revised back to 1963.III.

The newly estimated parameters are contained in Tables IV and V. The choice of time period for this reestimation was influenced by a belief that the portfolio adjustments of mutual savings banks were quite different before and after the mid-1960's. In the latter period the Pitfall's portfolio adjustment model seemed a workable approximation. In earlier years, however, MSB behavior was reportedly distorted by an aversion to realizing the substantial capital losses that had been incurred on the long term bonds in their portfolios.

In the earlier paper, we used the period 1966.I through 1972.IV for estimation and then backcast over the period 1955.I–1965.IV. Our prior means and mixed estimates of the parameters confirmed the existence of a sizeable gap between actual and desired long term bond holdings throughout the 1950's and early

Table IV

MSB Short-Run Coefficients

		Rate Responses						Adjustment Coefficients						
		1.0	$\frac{1}{r_{TD}}$	$\frac{1}{r_S}$	$\frac{1}{r_L}$	$\frac{1}{r_{BL}}$	$\frac{1}{r_M}$	$\frac{\varphi C + DD}{W^E}$	$\frac{\varphi TD}{W^E}$	$\frac{\varphi \text{Short}}{W^E}$	$\frac{\varphi \text{Long}}{W^E}$	$\frac{\varphi BL}{W^E}$	$\frac{\varphi \text{Mort}}{W^E}$	$\frac{S - S^E}{W^E}$
$\frac{C + DD}{W^E}$	priors	none	.000	.043	.112	−.002	−.080	1.0	.0	.025	.025	.1	.1	.2
	OLS	.128	−.008	−.000	.096	.013	−.162	1.811	−.014	.032	.158	.153	.091	.075
	mixed	.092	.002	.016	.073	−.010	−.126	1.009	.009	.033	.107	.127	.073	.094
$\frac{TD}{W^E}$	priors	none	−.002	.028	.002	−.004	.042	.0	1.0	.025	.025	.1	.0	.0
	OLS	.082	−.065	.012	.046	−.084	.118	.092	.684	.238	.049	−.106	.083	.031
	mixed	.017	−.005	.027	−.008	−.005	.032	.000	1.000	.025	.001	.098	.024	.006
$\frac{\text{Short}}{W^E}$	priors	none	.002	−.097	.226	.0	−.257	.0	.0	.95	.1	.2	.3	.4
	OLS	−.111	.043	−.053	−.087	.045	.124	−.153	−1.092	.223	−.104	.062	−.104	.067
	mixed	.280	.006	−.098	.209	.002	−.180	.012	.011	.961	.229	.237	.281	.282
$\frac{\text{Long}}{W^E}$	priors	none	.0	.026	−.765	.019	1.073	.0	.0	.0	.85	.0	.1	.1
	OLS	.798	−.043	.069	−.156	−.001	−.014	−1.193	1.435	.216	.841	.791	.805	.635
	mixed	.273	−.010	.063	−.707	.021	.904	−.024	−.023	−.023	.485	−.074	.272	.364
$\frac{BL}{W^E}$	priors	none	.0	.0	.0	−.024	.023	.0	.0	.0	.0	.6	.0	.0
	OLS	.039	−.044	.022	−.041	−.055	.164	.108	.632	.117	.240	.386	.036	.031
	mixed	.012	−.003	.011	−.022	−.021	.033	−.001	−.001	−.001	−.006	.594	.009	.026
$\frac{\text{Mort}}{W^E}$	priors	none	.0	.0	.425	0.10	−.800	.0	.0	.0	.0	.0	.5	.3
	OLS	.064	.117	−.050	.142	.083	−.228	.336	−.929	.173	.032	−.286	.090	.162
	mixed	.324	.009	−.019	.453	.012	−.661	.005	.004	.005	.183	.018	.336	.229

Table V

MSB Long Run Coefficients

$\frac{\alpha^*}{W^E}$	$\left(\frac{\alpha}{W}\right)$		1.0	$\frac{1}{r_{TD}}$	$\frac{1}{r_S}$	$\frac{1}{r_L}$	$\frac{1}{r_{BL}}$	$\frac{1}{r_M}$
$\frac{C+DD^*}{W^E}$	.02	priors	none	.0	.45	.050	.0	.038
		OLS	.024	−.019	−.000	.052	−.005	−.068
		mixed	.018	.004	.005	.199	−.010	−.291
$\frac{TD^*}{W^E}$	.01	priors	none	−.0025	.030	.025	.0	.0
		OLS	.012	−.097	.038	−.028	−.095	.133
		mixed	−.006	−.006	.032	−.070	−.002	.115
$\frac{\text{Short}^*}{W^E}$	.02	priors	none	.0025	−.105	.075	.0	.074
		OLS	−.012	−.106	−.055	−.065	−.152	.589
		mixed	.005	.004	−.110	.102	.000	.012
$\frac{\text{Long}^*}{W^E}$	.30	priors	none	.0	.030	−1.000	.020	1.450
		OLS	−.181	.457	−.029	.682	.139	−.637
		mixed	.035	−.053	.233	−3.199	.023	4.301
$\frac{BL^*}{W^E}$	.01	priors	none	.0	.0	.0	−.040	.038
		OLS	.087	−.187	.026	−.491	−.034	.472
		mixed	.006	−.006	.024	−.116	−.036	.164
$\frac{\text{Mort}^*}{W^E}$	.64	priors	none	.0	.0	.850	.020	−1.600
		OLS	1.111	−.175	.037	−.325	.091	−.312
		mixed	.945	.056	−.183	3.093	.025	−4.316

1960's. We were even so fortunate as to have desired holdings not exceed actual until 1965.III and 1965.IV respectively. For the out of sample forecasting tests, long term bond holdings were constrained to decrease by no more than 1% per quarter, with the difference allocated proportionately to the other asset forecasts. The pure priors forecast somewhat better, and the mixed estimates much better, than least squares.

In the present paper I have reestimated the model for the same period 1966.I–1972.IV and then expanded the out of sample quarters to include 1973.I–1976.IV as well as 1954.I–1965.IV. Again the mixed estimates are very similar to before and perhaps somewhat improved. In contrast, many of the least squares estimates have changed substantially; but as a group they remain implausible. A new wrinkle to this implausibility is that the OLS adjustment path is now actually unstable. With constant wealth and desired asset stocks, actual holdings move explosively away from desired. For example, the least squares time path for a desired $1 billion dollar switch from currency to mortgages is:

Qtrs	$C+DD$	TD	Short	Long	BL	Mort
1	.72	.01	−.05	−2.00	.07	1.25
2	−.39	−.05	−.01	−.52	.40	.99
3	.25	.06	.09	−1.59	.41	1.12
4	−.11	.03	−.10	−1.17	.57	1.13
8	.03	.08	−.03	−2.32	.86	1.87
20	.14	.30	−.18	−9.23	3.48	7.34
40	1.38	3.00	−1.81	−92.08	34.71	73.22

Table VI

MSB RMSE's for Out-of-Sample Forecasts (1954.I–1965.IV, 1973.I–1976.IV)

		Number of Quarters Ahead				
Variable	Method	1	2	4	6	8
	Priors	.588	.626	.626	.629	.642
	OLS	.617	.261	.261	.360	.363
$C + DD$	Mixed	.252	.263	.275	.283	.287
	*N*1	.103	.110	.118	.078	.069
	*N*2	.103	.111	.122	.134	.128
	Priors	.497	.506	.516	.527	.539
	OLS	.267	.350	.322	.301	.297
TD	Mixed	.380	.395	.393	.394	.393
	*N*1	.041	.064	.098	.103	.118
	*N*2	.041	.064	.084	.137	.278
	Priors	.794	.926	.975	.961	.962
	OLS	.391	.636	.783	.758	.723
SHORT	Mixed	.475	.532	.504	.500	.512
	*N*1	.146	.233	.369	.316	.337
	*N*2	.146	.247	.410	.520	.608
	Priors	.820	.838	.893	.952	1.049
	OLS	.688	.537	.598	.661	.606
LONG	Mixed	.689	.657	.863	.926	1.020
	*N*1	.420	.950	1.961	3.106	4.336
	*N*2	.420	.931	1.808	2.993	4.028
	Priors	.099	.114	.131	.138	.146
	OLS	.245	.245	.171	.163	.167
BL	Mixed	.138	.165	.175	.169	.165
	*N*1	.090	.102	.134	.074	.071
	*N*2	.090	.101	.130	.162	.232
	Priors	.944	1.233	1.353	1.368	1.374
	OLS	.948	1.123	1.368	1.407	1.447
MORT	Mixed	.822	1.053	1.186	1.286	1.315
	*N*1	.184	.392	.952	1.421	2.049
	*N*2	.184	.389	.927	1.401	2.779
	Priors	.682	.790	.842	.856	.879
	OLS	.583	.606	.712	.735	.734
$(\sum RMSE^2/6)^{5}$	Mixed	.517	.588	.667	.713	.731
	*N*1	.205	.435	.906	1.402	1.964
	*N*2	.205	.429	.850	1.370	2.019

The 1950's backcasts with the least squares model were also unimpressive. Forecast long holdings are more often above actual than below, and negative holdings of other assets are often predicted. The priors and mixed estimate consistently indicate excess holdings of long term bonds up until 1965.III.

The constrained out of sample predictions are reported in Table VI. Averaged across assets the rankings are consistently mixed best, then OLS, and then our pure priors. Again the forecasts are improved by combining data with priors. The naive models continue to do well in one and two quarter ahead predictions but fail more challenging tests.

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