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Fixed vs Stepwise Forecast Models to Predict Number of Pods with Beans per Soybean Plant in Southern States

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FIXED VS STEPWISE FORECAST MODELS TO PREDICT NUMBER OF PODS WITH BEANS PER SOYBEAN PLANT IN SOUTHERN STATES by Robert Battaglia and Benjamin Klugh, Research Division; Statistical Reporting Service; U. S. Department of Agriculture. Staff Report No. AGES850226.

ABSTRACT

The purpose of this research was to apply the forecast model analysis initiated in seven northern states to the remaining states in the soybean objective yield program. Forecast models developed using stepwise variable selection procedures were compared to regression models with one or two fixed variables in nine southern states. Results from 1977 to 1982 showed no significant difference in the forecasted number of pods with beans per plant from either method. A Bootstrap test for all soybean objective yield states for 1982 and 1983 showed no difference in forecasts.

Keywords: Stepwise variable selection, jackknife analysis, bootstrap analysis, outlier, and leverage points.

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SUMMARY

Regression models with one or two fixed variables performed as well as stepwise-created forecast models in predicting final numbers of pods with beans per soybean plant. Data from 1977 to 1982 was analyzed for nine southern soybean objective yield states. Models were created using six combinations of five years of data with the sixth year used as a forecast year. Stepwise and fixed-variable models were created for each state, maturity category, and month combination. The variables in the fixed models were determined from Arkansas data, the state with the largest sample size. Results of a jackknife evaluation procedure for the fixed and stepwise models across all nine states were compared using four forecast statistics: average deviation; average absolute deviation; root mean square error (MSE); and relative efficiency. A bootstrap test on 1982 and 1983 data from all fifteen soybean objective yield states showed no difference in MSE's from stepwise or fixed models.

A trend analysis of the dependent and independent variables across all six years of data produced significant results ($\alpha = .05$) in eleven percent of the models over all months and maturity categories. A significant relationship was observed between lateral branches and time.

Adopting these fixed-variable models would simplify forecast model creation procedures, provide consistent and comparable relationships across years for forecasting final numbers of pods with beans per plant; and simplify late season data collection.

We recommend adoption of the fixed-variable forecast models for the soybean objective yield program.

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INTRODUCTION

Forecast models to predict pods with beans per plant in the soybean objective yield survey are presently developed using the five most recent years of data in a stepwise variable selection procedure. Number of pods with beans per plant at maturity in the six-inch detailed count section is the dependent variable. The candidate independent variables are counts of plants, mainstem nodes, blooms, pods, lateral branches, and simple transformations of these as listed in Table 1. A unique stepwise model is created for each maturity category for each state and month. Approximately 110 unique models are created each year for the nine southern soybean states of Alabama, Arkansas, Georgia, Louisiana, Mississippi, Missouri (District 2), North Carolina, South Carolina, and Tennessee.

The objective of this study is to compare regression models with one or two fixed variables to models developed using a stepwise variable selection procedure to forecast the final number of pods with beans per soybean plant.

Development of the same forecast models with one or two fixed variables to be applied in each maturity category within a month in all nine states would provide consistent and comparable relationships across years. The models will be less complex, and would permit field office personnel greater insight into yield forecasts. The data requirements for these models could reduce the number of late season data counts.

The analysis employed soybean objective yield data from nine southern soybean states over the six year period from 1977 to 1982. These states were grouped since determinant soybean varieties are grown in each one. Data from Arkansas, the state with the largest sample size, was used to determine the fixed-variable models to be applied in all nine states. The models were not always the same as those used in the northern state analysis.

METHODS

The data for this study was collected in nine southern states from 1977 to 1982 and was used to create soybean objective yield forecast models for the operating program. There were 5 steps in creating the model. Stepwise models for each state were separately developed using steps 1 and 2. Fixed models were developed in step 3 and a jackknife procedure used to compare them with the stepwise models in step 4. In the final step forecasts were compared using a bootstrap test. All models in this analysis were developed using the same outlier and leverage point detection procedures as in the operating program.

The first of the five steps in the analysis was to use an automated procedure to identify and remove the extreme outlier and leverage values from the raw data. Outliers are data points that significantly influence the intercept of a model while leverage points significantly influence slopes. A regression model was created which included all six independent variables. This was done for each maturity category within state, month, and objective yield district. Two diagnostic statistics, the deleted residual and Cook's D (5), were then calculated for the raw data to identify outlier and leverage data points. Identified outliers and leverage points were removed using SAS.

The automated analysis procedure used to identify the outliers and leverage points examined the data four times. In each examination, regression coefficients and diagnostic statistics were calculated. On the first pass, regression statistics and diagnostics were computed for the entire data set. Outlier and leverage points were identified and excluded from further calculation. In the second pass, analysis was conducted on the remaining data. Outlier and leverage points were again identified and excluded from further calculation. During the third pass, observations which had been deleted during the first two passes were examined using a 95% confidence interval for an observable Y. Previously deleted values within this confidence interval were reinserted into the data set for final model calculation. On the fourth pass, final model parameters and diagnostics were computed. This automated procedure was used to create all the models in the analysis and is identical to the operational procedure now in use.

The second step in the analysis was to use the cleaned data from step 1 in a jackknife variable selection procedure. In the jackknife analysis procedure the six years of data were divided into six combinations of five years of data with a different year removed from each combination. A separate stepwise analysis was applied to each different group of five data years for each maturity category within month and state. A model specified by the stepwise selection procedure could contain up to six independent variables, many of which are highly correlated (See Appendix II). The same set of variables for a given maturity category, month, and state were rarely selected for different five year goups by the stepwise variable selection procedure.

TABLE 1 --Independent Variables Used to Forecast Final Pods With Beans Per Plant, in the Soybean Objective Yield Program

Variable	Description of Current Month Form B Counts
X8	(Plants per 18 sq. ft)^2, counts in 42 inch row section.
X9	Mainstem nodes per plant, 6 inch row section. if sample maturity category = 1 to 3. OR (Pods with developing beans per plant)^2, 6 inch row section. if sample maturity category = 4 to 10.
X10	Blooms and pods per plant, counts in 6 inch row sections.
X12	Pods with developing beans per plant, counts in 6 inch row section.
X14	Lateral branches with blooms or pods per plant, counts in 6 inch row sections.
X15	Plants per 18 sq. ft., counts in 42 inch row section.

In step three, the clean Arkansas data was used to develop one- or two-variable forecast models for comparison with the models specified by stepwise selection. A jackknife forecast procedure was used on the six five-year periods of Arkansas data to select the final models. Data was fit to each five-year group with the excluded year used for forecasting. Average deviations, average absolute deviations, and root mean square errors for the six forecast years were compared to select the best candidate models (See Table 2). An "all possible regressions" procedure applied to the Arkansas data supported the models selected. The structural stability and validity of the models was verified from an examination of coefficients, partial regression plots, and collinearity diagnostics. Many of these models were the same as those identified for the northern states (1). When several candidate models were equivalent in terms of forecast performance, the corresponding model from the northern states analysis was selected. Finally, and "all possible regression" procedure applied to all nine states supported the selected fixed models.

Variables in most of the fixed-variable forecast models showed a logical progression starting with plants and lateral branches in September to pods with beans in November. Lateral branches with pods was a much more important variable in the southern states and the variables selected for the forecast models were more consistent across maturity categories. Appendix I contains descriptions of all maturity categories.

Table 2 -- Final Fixed Variable Models Selected From Arkansas Data

Month	Maturity	Final Forecast Variables
Sept	2	Plants (X15), Lateral branches with pods (X14)
Sept	3	Lateral branches with pods (X14), Total blooms + pods (X10)
Sept	4	Lateral branches with pods (X14), Total blooms + pods (X10)
Sept	5	Lateral branches with pods (X14), Total blooms + pods (X10)
Sept	6	Lateral branches with pods (X14), Pods with beans (X12)
Sept	7	Pods with beans (X12)
Sept	8	Pods with beans (X12)
Oct	6	Lateral branches with pods (X14), Pods with beans (X12)
Oct	7	Pods with beans (X12)
Oct	8	Pods with beans (X12)
Oct	9	Pods with beans (X12)
Nov	9	Pods with beans (X12)

In the fourth step the stepwise models from step 2 and the fixed models from step 3 were compared using a jackknife forecast procedure for all nine states. This comparison simulated forecasting as long as a significant time trend was not present in the data.

Stepwise and fixed model parameters were calculated again using the automated diagnostic procedure for each of the six combinations of five years of data. Model forecasts were created after each fit for the single year not used to build the model. Forecast performance was evaluated, by state, on the basis of four statistics: average deviation, average absolute deviation, root mean square error, and relative efficiency. The first three statistics were produced for each of the six forecast years while the relative efficiency was calculated over the six years. The relative efficiency was defined as a ratio of the sum of squared errors (SSE) of the fixed model to those of the stepwise model. A relative efficiency less than one indicated the fixed model produced smaller forecast errors than the stepwise model. To calculate relative efficiency, the error sum of squares of both the numerator and denominator were aggregated separately and the ratio computed. To create the six-year error sum of squares for a state, each of the six yearly error sums of squares was added together. The sampling rate within all states between years was quite similar, allowing count data to be appropriate.

An aggregated relative efficiency was also computed over the nine states. A similar aggregation procedure for the error sum of squares was employed across states as was used within states. Comparing this across-state procedure to using average state acreages as weights produced little difference in the calculated values and no difference in conclusion.

The nine-state relative efficiency was used to evaluate the performance of the final fixed models versus the operational stepwise models. The model coefficients and their standard errors for the final models were examined for statistical differences over the six-year period. The dependent and independent variables were also examined for trend relationships. If trend is significant in many cases, the jackknife procedure is invalid.

Finally a bootstrap test was conducted using data from all fifteen soybean states. Stepwise and fixed-variable forecasts for 1982 and 1983 were based on models developed using five previous years of data, as in the operational program. The mean squared errors (MSE) of the forecasts from each method were then compared by maturity category within month within state.

RESULTS

Correlation coefficients of the six independent variables were reviewed prior to construction of the fixed-variable models. Appendix II lists the correlation coefficients of highly correlated variables by month and maturity category. It was subjectively decided to include variables in Appendix II where the absolute value of r was greater than 0.7. This table also lists the correlation coefficients of the independent variables in the final fixed forecast models. The table shows that the number of highly correlated variables increases as the plant develops during the growing season. It is no surprise that these variables are highly correlated when the data collection definitions (Table 1) are examined. Forecast models developed using the current stepwise procedures tend to include those highly correlated variables. The result is marginally higher R^2 values and a marginal increase in the variability in estimates of the model parameters.

TABLE 3 - Aggregated Relative Efficiency (RE) of Fixed Models vs. Stepwise Models in Nine Southern States, 1977-82

Month	Maturity	Final Forecast Variables 1/	Aggregated RE
Sept	2	Lateral branches with pods (X14), Plants (X15)	.89
Sept	3	Lateral branches with pods (X14), Total blooms + pods (X10)	.97
Sept	4	Lateral branches with pods (X14), Total blooms + pods (X10)	.91
Sept	5	Lateral branches with pods (X14), Total blooms + pods (X10)	.94
Sept	6	Lateral branches with pods (X14), Pods with beans (X12)	1.02
Sept	7	Pods with beans (X12)	.98
Sept	8	Pods with beans (X12)	1.05
Oct	6	Lateral branches with pods (X14), Pods with beans (X12)	.90
Oct	7	Pods with beans (X12)	1.22
Oct	8	Pods with beans (X12)	1.03
Oct	9	Pods with beans (X12)	.83
Nov	9	Pods with beans (X12)	.92

1/ See Table 1 for complete description of variables.

The relative efficiencies of the forecasts from the final fixed models, applied across all nine states, are presented in Table 3. The fixed models generally had smaller mean square errors than the stepwise models. In four month and maturity category combinations, the fixed models were outperformed by stepwise but only one maturity category in October had difference in RE greater than 5%. The RE for all states is aggregated over the six forecast years.

A test of equality was applied to determine if differences in MSE's produced by fixed and stepwise models across states were statistically significant. Since objective yield forecasts are produced by month, the MSE's of the number of pods per plant forecasts were compared by month over the six-year period. A weighted average monthly MSE was created by weighting the MSE's within a month by number of observations per maturity category, summing over all nine states, and dividing by the total number of observations. These results are presented in Table 4.

Table 4 - Sign Test of Weighted Average Mean Square Errors, Across All States, by Forecast Month and Year (Fixed - Stepwise)

Month	Model	1977	1978	1979	1980	1981	1982
Sept	Fixed	107	100	141	124	111	132
	Stepwise	111	142	117	129	100	108
	Sign 1/	-	-	+	-	+	+
Oct	Fixed	15.5	17.8	19.6	14.5	22.7	14.7
	Stepwise	15.8	18.4	18.1	14.1	27.6	17.0
	Sign	-	-	+	+	-	-
Nov	Fixed	2.60	5.62	1.96	5.14	1.35	
	Stepwise	2.56	5.70	2.04	5.10	30.1	2/
	Sign	+	-	-	+	-	

1/ A plus sign indicates that the MSE (stepwise) less than MSE (fixed)
2/ Less than 10 observations

A nonparametric sign test was used to determine if a significant difference between MSE's existed. This was necessary since the assumption of independence necessary for an F test was violated. When the variables used for the fixed and stepwise models were the same, the models are not independent. The hypotheses were:

H_o: MSE(STEPWISE) = MSE(FIXED), P[+] = .5

H_1: MSE(STEPWISE) < MSE(FIXED), P[+] > .5

The data for each month in Table 5 is a binomial distribution b(n, 0 .5) under the null hypothesis which should be rejected for large numbers of plus signs. Power curves were constructed to find the rejection region which best controlled Type I and Type II errors. The rejection region was established at 5 or more plus signs with an alpha level of significance of 0.109. The null hypothesis is not rejected for any month, indicating no difference between fixed or stepwise forecast MSE's. Monthly MSE's are given for the models for each of the nine states in Appendix III.

Table 5: Sign Test Results for 1982-83 Bootstrap Test

Month	Year	n	Number of + Signs 1/	Significance Probability
Aug.	82	7	4	.50
	83	6	3	.66
Sept.	82	15	9	.30
	83	14	5	.91
Oct.	82	7	3	.72
	83	14	6	.79

1/ A plus sign indicates that the MSE for the stepwise model was less than the MSE for the fixed model.

A similar one-tailed sign test was applied to the bootstrap results by month and year. The number of states available each month, the number of times that the MSE (stepwise) was less than the MSE (fixed), and the probability of a significant test are listed in Table 5. The stepwise models will be significantly better than fixed models for probabilities smaller than 0.1. None of the six probabilities are significant and the conclusion is that no differences exist between the fixed and stepwise modeling procedures. Monthly mean square errors for each state and year are contained in Appendix IV.

The model coefficients and their standard errors for the final fixed forecast models were next examined. The coefficients for almost all models in all states were found to be stable in sign, similar in order of magnitude, and significantly different from zero. The Arkansas and Mississippi coefficients and standard errors appear in Appendix V.

Finally a trend analysis was completed on the six years of data for all variables by state, month, and maturity. Weak trends, ($b \neq 0, \alpha = 0 .05$ with $R^2 = (0.12)$), for the dependent variable were found in 11 percent of the models across all months and maturity categories. This fact would weaken the use of a jackknife procedure in evaluating true forecast performances but not invalidate model comparisons. For the models where a significant time trend or an external mechanism related to time did not exist in the data, a jackknife procedure could be used to evaluate forecast performance. Twelve of 109 models were thus influenced. Weak trends for the numbers of lateral branches variable were found over almost all categories and months in which the correlation coefficient was not equal to zero with $\alpha = 0.2$.

CONCLUSIONS AND RECOMMENDATIONS

The fixed models performed as well as the stepwise models in forecasting the number of pods per plant for the analysis period. When employing a jackknife evaluation method time trend analysis showed a weak trend in 11 percent of the models, which does not invalidate the model I comparison. The bootstrap test conducted in each soybean state for 1982 and 1983 showed no difference in the MSE's of forecasts from fixed or stepwise models.

Adoption of a set of fixed models for maturity categories within month, applied across all nine states would greatly simplify forecast model creation procedures and model performance evaluation. Consistent relationships between the final number of pods with beans and the independent variables could give field office personnel greater insight into objective yield forecast procedures.

We recommend adoption of the fixed-variable forecast models suggested in (1) and in this current paper for the operational soybean objective yield program.

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APPENDIX I - SOYBEAN OBJECTIVE YIELD MATURITY CATEGORY DEFINITIONS

Maturity Category	Description
0	No plants were present in either row of the two 6-inch row section.
1	No pods with beans are present and the ratio of total fruit to mainstem nodes is less than .20.
2	No pods with beans are present and the ratio of total fruit to mainstem nodes is between .20 and 1.75.
3	No pods with beans are present and the ratio of total fruit to mainstem nodes is greater than 1.75.
4	Pods with beans are present and the ratio of pods with beans to total fruit is less than .05.
5	The ratio of pods with beans to total fruit is between .05 and .2.
6	The ratio of pods with beans to total fruit is between .20 and .65.
7	The ratio of pods with beans to total fruit is between .65 and .85.
8	Pods filled, leaves turning yellow or the ratio of pods with beans to total fruit is greater than .85.
9	Pods turning brown, leaves shedding.
10	Pods brown, almost mature or pods mature.

APPENDIX II - CORRELATION COEFFICIENTS OF SELECTED VARIABLES, [1/] 1977-82

Month	Maturity Category	Indep. Variable With |r| > .7 Variables		r	Pr > |r|	r of Variables in Final Models Variables		r	Pr > |r|
Sept	2	X15	X8	.966	.0001	X15	X14	-.262	.0053
	3	X15	X8	.924	.0001	X14	X10	.592	.0001
	4	X15	X8	.958	.0001	X14	X10	.494	.0001
		X12	X10	.700	.0001				
		X12	X9	.927	.0001				
	5	X15	X8	.935	.0001	X14	X10	.530	.0001
		X12	X10	.817	.0001				
		X12	X9	.923	.0001				
		X10	X9	.711	.0001				
	6	X15	X8	.951	.0001	X14	X12	.604	.0001
		X12	X10	.836	.0001				
		X12	X9	.932	.0001				
		X10	X9	.767	.0001				
	7	X15	X8	.949	.0001	X12		-	-
		X14	X12	.792	.0001				
		X14	X10	.797	.0001				
		X12	X10	.994	.0001				
		X12	X9	.914	.0001				
		X10	X9	.911	.0001				
	8	X15	X8	.912	.0001	X12		-	-
		X14	X12	,740	.0001				
		X14	X10	.802	.0001				
		X12	X10	.860	.0001				
		X12	X9	.912	.0001				
		X10	X9	.807	.0001				
Oct	6	X15	X8	.956	.0001	X14	X12	.738	.0001
		X14	X12	.738	.0001				
		X14	X10	.732	.0001				
		X12	X10	.951	.0001				
		X12	X9	.922	.0001				
		X10	X9	.845	.0001				

Month	Maturity Category	Indep. Variable With $|r| > .7$ Variables		r	$Pr > |r|$	r of Variables in Final Models Variables	r	$Pr > |r|$
Oct	8	X15	X8	.916	.0001	X12	-	-
		X14	X12	.746	.0001			
		X14	X10	.736	.0001			
		X12	X10	.980	.0001			
		X12	X9	.924	.0001			
		X10	X9	.904	.0001			
	9	X15	X8	.961	.0001	X12	-	-
		X12	X10	.985	.0001			
		X12	X9	.948	.0001			
		X10	X9	.934	.0001			
Nov	9	X15	X8	.966	.0001	X12	-	-
		X14	X12	.806	.0001			
		X14	X10	.808	.0001			
		X14	X9	.731	.0001			
		X12	X10	.991	.0001			
		X12	X9	.937	.0001			
		X10	X9	.930	.0001			

1/ Correlation coefficients were computed across all seven states by month and maturity category.

APPENDIX III MEAN SQUARE ERRORS BY STATE, MONTH, AND YEAR FOR PODS PER PLANT FORECASTS FROM FIXED (F) VERSUS STEPWISE (S) MODELS[1/]

Alabama (1)

Month	Model	1977	1978	1979	1980	1981	1982
Sept	F	113	60	102	110	-	-
	S	113	144	101	117	-	-
Oct	F	16.4	12.7	12.2	10.5	10.1	6.4
	S	16.6	12.7	12.9	11.3	10.7	6.6
Nov	F	0	2/	2/	2/	2/	-
	S	0	2/	2/	2/	2/	-

Arkansas (5)

Month	Model	1977	1978	1979	1980	1981	1982
Sept	F	85	62	192	62	-	-
	S	128	61	80	66	-	-
Oct	F	14.1	18.6	23.6	17.9	25.9	18.8
	S	14.6	16.9	24.5	17.7	78.5	17.1
Nov	F	4.40	2/	2/	5.63	2/	-
	S	4.27	2/	2/	5.83	2/	-

Georgia (13)

Month	Model	1977	1978	1979	1980	1981	1982
Sept	F	134	128	162	136	-	-
	S	135	126	159	142	-	-
Oct	F	10.4	14.1	11.1	10.7	16.2	9.7
	S	10.4	14.2	10.7	10.5	16.5	11.1
Nov	F	1.02	2/	2/	2/	2/	-
	S	1.02	2/	2/	2/	2/	-

Louisiana (22)

Month	Model	1977	1978	1979	1980	1981	1982
Sept	F	157	102	155	223	-	-
	S	178	228	164	261	-	-
Oct	F	18.3	17.7	20.7	11.0	16.8	12.9
	S	17.3	16.5	21.1	10.9	15.6	12.1
Nov	F	-	-	-	-	-	-
	S	-	-	-	-	-	-

Mississippi (28)

Month	Model	1977	1978	1979	1980	1981	1982
Sept	F	111	97	171	147	-	-
	S	116	109	160	149	-	-
Oct	F	20.1	29.9	39.8	26.7	20.1	23.1
	S	20.5	29.0	27.3	24.5	23.7	24.6
Nov	F	7.20	2/	2/	20.2	2/	-
	S	6.83	2/	2/	20.21	2/	-

Missouri (29) Dist. II

Month	Model	1977	1978	1979	1980	1981	1982
Sept	F	63	87	101	44	111	59
	S	46	76	95	46	100	48
Oct	F	25.1	14.5	8.6	5.8	131.0	12.2
	S	27.2	14.8	9.4	6.3	52.3	10.2
Nov	F	-	-	-	-	-	
	S	-	-	-	-	-	

North Carolina (37)

Month	Model	1977	1978	1979	1980	1981	1982
Sept	F	126	185	116	79	-	-
	S	122	204	107	75	-	-
Oct	F	9.9	11.3	12.8	10.1	7.6	13.3
	S	11.1	21.8	12.9	9.2	9.8	13.2
Nov	F	1.91	2/	1.53	.78	1.46	-
	S	1.91	2/	1.53	.78	2.53	-

South Carolina (45)

Month	Model	1977	1978	1979	1980	1981	1982
Sept	F	105	163	106	196	-	-
	S	107	346	96	174	-	-
Oct	F	21.0	12.5	13.7	19.8	12.2	13.2
	S	21.0	13.2	14.0	20.5	11.2	14.3
Nov	F	3.92	2/	1.80	2.78	2/	-
	S	3.92	2/	1.80	2.78	2/	-

Tennessee (47)

Month	Model	1977	1978	1979	1980	1981	1982
Sept	F	70	53	103	90	-	-
	S	75	53	103	93	-	-
Oct	F	8.1	19.7	18.9	9.3	20.4	14.4
	S	8.9	18.2	18.4	8.5	20.1	14.4
Nov	F	-	-	-	-	-	-
	S	-	-	-	-	-	-

1/ The monthly MSE was calculated by weighting the MSE of each maturity category within the month using the number of observations per maturity category as weights.

2/ Less than 10 observations

APPENDIX IV

Weighted Average Mean Square Error Bootstrap Results for Fixed (F) and Stepwise (S) Models by State and Month for 1982 and 1983.

1982

Month	Model	Ill.	Ind.	Iowa	Minn	Mo(1)	Mo(2)	Neb.	Ohio
Aug.	F	86	145	110	49	292	59	-	51
	S	81	148	118	27	290	48	-	59
	Sign 1/	+	-	-	+	+	+		-
Sept.	F	17.9	27.5	27.7	18.7	35.0	12.2	-	14.9
	S	17.7	27.9	25.0	17.3	30.7	10.2		14.1
	Sign	+	-	+	+	+	+		+
Oct.	F	3.67	6.40	5.32	3.84	5.33	-	3.86	1.93
	S	3.73	2.22	5.33	3.49	9.09	-	9.25	1.91
	Sign	-	+	-	+	-		-	+

month	model	AL	ARK	GA	LA	Miss	NC	SC	Tenn
Sept.	F	-	-	-	-	-	-	-	-
	S	-	-	-	-	-	-	-	-
	Sign								
Oct.	F	6.4	18.8	9.7	12.9	23.1	13.3	13.2	14.4
	S	6.6	17.1	11.1	12.1	24.6	13.2	14.3	14.4
	Sign	-	+	-	+	-	+	-	0
Nov.	F	-	-	-	-	-	-	-	-
	S	-	-	-	-	-	-	-	-
	Sign								

1/ + = MSE [Stepwise (S)] < MSE [Fixed (F)]
- = MSE [Stepwise (S)] > MSE [Fixed (F)]

Weighted Average Mean Square Error Bootstrap Results for Fixed (F) and Stepwise (S) Models by State and Month for 1982 and 1983

1983

Month	Model	Ill.	Ind.	Iowa	Minn	Mo(1)	Mo(2)	Neb.	Ohio
Aug.	F	107	203	155	72	199	-	-	119
	S	98	195	163	73	356	-	-	115
	Sign	+	+	-	-	-			+
Sept.	F	25.6	37.4	49.4	27.9	88.7	125	-	29.1
	S	30.5	37.0	50.0	30.6	112	131		28.6
	Sign	-	+	-	-	-	+		+
Oct.	F	33.3	12.4	13.8	2.63	18.7	25.0	7.79	10.3
	S	33.4	12.4	12.9	2.79	18.9	26.9	8.65	10.3
	Sign	-	0	+	-	-	-	-	0

Month	Model	AL	ARK	GA	LA	MISS	NC	SC	TENN
Sept.	F	144	356	167	173	273	185	299	266
	S	144	357	295	191	243	179	289	295
	Sign	0	-	-	-	+	+	+	-
Oct.	F	13.3	363	47.4	27.1	28.1	36.9	60.4	18.2
	S	14.3	355	45.5	35.4	23.0	35.5	66.2	15.0
	Sign	-	+	+	-	+	+	-	+
Nov.	F	-	-	-	-	-	-	-	-
	S	-	-	-	-	-	-	-	-
	Sign								

APPENDIX V: FIXED MODEL COEFFICIENTS AND STANDARD ERRORS FOR THE SIX JACKKNIFE ANALYSES IN ARKANSAS AND MISSISSIPPI

Model coefficients and standard errors of fixed variable forecast models, for Arkansas and Mississippi, are listed in the following tables by maturity category within month. There are six sets of coefficients for each model which correspond to the six forecast years starting with 1977 and ending with 1982.

ST = 5 Arkansas

ST = 28 Mississippi

ST=5 MON=2 MAT=2

INT	SE	X10	SE10	X12	SE12	X14	SE14	X15	SE15
8.7010	3.35607	0	0	0	0	7.74248	2.10815	0.0006458	0.0585755
8.7010	3.35607	0	0	0	0	7.74248	2.10815	0.0006458	0.0585755
10.2957	4.45062	0	0	0	0	7.71438	2.96855	0.0161972	0.0856609
6.5099	3.12093	0	0	0	0	0.54618	2.87482	0.0265459	0.0534669
7.9607	3.57895	0	0	0	0	8.27309	2.24046	0.0010715	0.0609748
9.5515	3.97841	0	0	0	0	8.09641	2.81042	-0.0073499	0.0672284

ST=5 MON=2 MAT=3

INT	SE	X10	SE10	X12	SE12	X14	SE14	X15	SE15
5.51314	1.04841	0.097978	0.0241608	0	0	5.03156	0.481359	0	0
5.51314	1.04841	0.097978	0.0241608	0	0	5.03156	0.481359	0	0
7.64677	1.46130	0.085571	0.0298806	0	0	4.65025	0.587965	0	0
3.09145	1.27359	0.125975	0.0323882	0	0	4.45430	0.546170	0	0
5.48830	1.20953	0.082532	0.0269186	0	0	5.66001	0.536800	0	0
4.86708	1.07086	0.101251	0.0256753	0	0	5.10269	0.590790	0	0

ST=5 MON=2 MAT=4

INT	SE	X10	SE10	X12	SE12	X14	SE14	X15	SE15
1.58834	1.40407	0.106040	0.0207565	0	0	4.08962	0.492376	0	0
1.58834	1.40407	0.106040	0.0207565	0	0	4.08962	0.492376	0	0
2.12688	1.72900	0.115691	0.0244539	0	0	3.72095	0.589474	0	0
-0.81167	1.76118	0.188751	0.0293772	0	0	3.17111	0.587471	0	0
0.65553	1.57770	0.099220	0.0215997	0	0	4.27336	0.514701	0	0
4.56205	1.70355	0.061896	0.0259404	0	0	4.62648	0.674831	0	0

ST=5 MON=2 MAT=5

INT	SE	X10	SE10	X12	SE12	X14	SE14	X15	SE15
3.12537	1.39645	0.109391	0.0179546	0	0	3.21862	0.368470	0	0
3.12537	1.39645	0.109391	0.0179546	0	0	3.21862	0.368470	0	0
2.18682	1.65416	0.133816	0.0227707	0	0	2.85465	0.478936	0	0
2.12454	1.53301	0.103928	0.0211242	0	0	3.22302	0.409926	0	0
3.85775	1.65153	0.096281	0.0205883	0	0	3.28350	0.414466	0	0
4.72939	1.56197	0.095460	0.0189292	0	0	3.57658	0.402683	0	0

ST=5 MON=2 MAT=6

INT	SE	X10	SE10	X12	SE12	X14	SE14	X15	SE15
2.19780	0.87077	0	0	0.610313	0.0320223	1.95337	0.237605	0	0
2.19780	0.87077	0	0	0.610313	0.0320223	1.95337	0.237605	0	0
2.66085	0.98589	0	0	0.631981	0.0355419	1.78182	0.268044	0	0
1.35736	0.92964	0	0	0.565123	0.0354508	2.43946	0.281312	0	0
1.92447	1.04383	0	0	0.627541	0.0377386	1.64356	0.274783	0	0
2.83440	1.09281	0	0	0.606867	0.0391696	2.09025	0.280944	0	0

ST=5 MON=2 MAT=7

INT	SE	X10	SE10	X12	SE12	X14	SE14	X15	SE15
4.66311	2.00375	0	0	0.747472	0.045839	0	0	0	0
4.66311	2.00375	0	0	0.747472	0.045839	0	0	0	0
5.58118	2.01419	0	0	0.717468	0.045641	0	0	0	0
3.28748	2.09878	0	0	0.795532	0.050111	0	0	0	0
3.81146	2.25750	0	0	0.756623	0.048806	0	0	0	0
-0.95380	3.73003	0	0	0.954852	0.104190	0	0	0	0

ST=5 MON=2 MAT=8

INT	SE	X10	SE10	X12	SE12	X14	SE14	X15	SE15
1.4251	1.93977	0	0	0.81391	0.0506715	0	0	0	0
1.4251	1.93977	0	0	0.81391	0.0506715	0	0	0	0
1.4251	1.93977	0	0	0.81391	0.0506715	0	0	0	0
1.0905	1.53659	0	0	0.78471	0.0404726	0	0	0	0
7.4346	3.95190	0	0	0.74793	0.0999429	0	0	0	0
-2.8190	2.37862	0	0	1.03483	0.0758179	0	0	0	0

-------------------------------- ST=5 MON=3 MAT=6 --------------------------------

INT	SE	X10	SE10	X12	SE12	X14	SE14	X15	SE15
1.25762	0.507503	0	0	0.787487	0.0326528	0.450130	0.229456	0	0
0.67453	0.452275	0	0	0.759158	0.0374374	0.803119	0.237662	0	0
0.85735	0.637833	0	0	0.831100	0.0371714	0.319706	0.259654	0	0
0.93520	0.467207	0	0	0.790223	0.0320526	0.605761	0.232439	0	0
0.91822	0.464664	0	0	0.794685	0.0320979	0.497120	0.228950	0	0
1.06660	0.421930	0	0	0.799509	0.0286032	0.398384	0.219439	0	0

-------------------------------- ST=5 MON=3 MAT=7 --------------------------------

INT	SE	X10	SE10	X12	SE12	X14	SE14	X15	SE15
1.79094	0.616190	0	0	0.805404	0.0183207	0	0	0	0
1.76375	0.586261	0	0	0.807203	0.0175067	0	0	0	0
2.14299	0.683319	0	0	0.807847	0.0202691	0	0	0	0
1.21926	0.538206	0	0	0.863073	0.0181736	0	0	0	0
1.89001	0.636790	0	0	0.801126	0.0185427	0	0	0	0
2.70949	0.705590	0	0	0.793105	0.0236130	0	0	0	0

-------------------------------- ST=5 MON=3 MAT=8 --------------------------------

INT	SE	X10	SE10	X12	SE12	X14	SE14	X15	SE15
0.664181	0.296581	0	0	0.867851	0.00833807	0	0	0	0
0.271687	0.274571	0	0	0.879434	0.00792211	0	0	0	0
0.193010	0.299076	0	0	0.882606	0.00807814	0	0	0	0
0.410269	0.281516	0	0	0.885272	0.00811132	0	0	0	0
0.222149	0.303893	0	0	0.875689	0.00835384	0	0	0	0
0.219313	0.310167	0	0	0.890277	0.00883302	0	0	0	0

-------------------------------- ST=5 MON=3 MAT=9 --------------------------------

INT	SE	X10	SE10	X12	SE12	X14	SE14	X15	SE15
0.068274	0.396333	0	0	0.966522	0.0126505	0	0	0	0
0.205768	0.394784	0	0	0.963169	0.0128311	0	0	0	0
0.087275	0.355732	0	0	0.969871	0.0112646	0	0	0	0
0.304806	0.374077	0	0	0.969275	0.0113671	0	0	0	0
0.032647	0.375967	0	0	0.965357	0.0114674	0	0	0	0
0.230292	0.366857	0	0	0.960088	0.0114030	0	0	0	0

-------------------------------- ST=5 MON=4 MAT=9 --------------------------------

INT	SE	X10	SE10	X12	SE12	X14	SE14	X15	SE15
-0.61238	0.220265	0	0	1.02360	0.0145241	0	0	0	0
-0.63201	0.227669	0	0	1.02412	0.0149577	0	0	0	0
-0.74595	0.666643	0	0	1.04795	0.0344678	0	0	0	0
-0.61098	0.220438	0	0	1.02436	0.0146035	0	0	0	0
-0.42119	0.219993	0	0	0.99711	0.0167169	0	0	0	0
-0.44677	0.211835	0	0	1.00798	0.0149682	0	0	0	0

------------------------------ ST=28 MON=2 MAT=2 ------------------------------

INT	SE	X10	SE10	X12	SE12	X14	SE14	X15	SE15
9.2592	3.84084	0	0	0	0	7.0302	2.07803	-0.059769	0.0631465
9.2592	3.84084	0	0	0	0	7.0302	2.07803	-0.059769	0.0631465
6.6966	4.06396	0	0	0	0	-0.0736	2.73881	0.011525	0.0826583
7.7265	3.42853	0	0	0	0	10.2451	1.98266	-0.048140	0.0566770
10.6548	5.68770	0	0	0	0	6.5964	2.64270	-0.077461	0.0810315
7.7828	3.00341	0	0	0	0	5.1201	1.91079	-0.008676	0.0519983

------------------------------ ST=28 MON=2 MAT=3 ------------------------------

INT	SE	X10	SE10	X12	SE12	X14	SE14	X15	SE15
0.6690	1.27213	0.124139	0.0181083	0	0	4.41595	0.405055	0	0
0.6690	1.27213	0.124139	0.0181083	0	0	4.41595	0.405055	0	0
-1.8008	1.75232	0.220459	0.0294734	0	0	3.66136	0.583542	0	0
0.1205	1.28764	0.147393	0.0179317	0	0	3.47188	0.413796	0	0
1.4879	1.47616	0.095531	0.0203595	0	0	4.82320	0.463148	0	0
1.2362	1.32042	0.090987	0.0186930	0	0	5.32407	0.452780	0	0

------------------------------ ST=28 MON=2 MAT=4 ------------------------------

INT	SE	X10	SE10	X12	SE12	X14	SE14	X15	SE15
1.66724	2.97506	0.124865	0.0566628	0	0	2.65125	0.94441	0	0
1.66724	2.97506	0.124865	0.0566628	0	0	2.65125	0.94441	0	0
3.99955	3.21107	0.130633	0.0570997	0	0	1.75842	0.93076	0	0
0.51198	3.19106	0.135144	0.0609251	0	0	2.46294	0.99138	0	0
0.79716	4.01237	0.093012	0.0877599	0	0	3.38313	1.48620	0	0
0.50001	3.13314	0.140739	0.0591734	0	0	2.85080	1.07391	0	0

------------------------------ ST=28 MON=2 MAT=5 ------------------------------

INT	SE	X10	SE10	X12	SE12	X14	SE14	X15	SE15
3.25922	1.50663	0.0627153	0.0223975	0	0	3.98223	0.468541	0	0
3.25922	1.50663	0.0627153	0.0223975	0	0	3.98223	0.468541	0	0
2.16869	1.58757	0.0739224	0.0276949	0	0	4.22726	0.492133	0	0
2.44610	1.31181	0.0952011	0.0200071	0	0	2.58512	0.464537	0	0
3.40213	2.05441	0.0571600	0.0257191	0	0	4.11133	0.571926	0	0
3.72410	1.74545	0.0612503	0.0283978	0	0	4.05432	0.672737	0	0

------------------------------ ST=28 MON=2 MAT=6 ------------------------------

INT	SE	X10	SE10	X12	SE12	X14	SE14	X15	SE15
3.34017	1.48347	0	0	0.825419	0.0547920	1.13797	0.363098	0	0
3.34017	1.48347	0	0	0.825419	0.0547920	1.13797	0.363098	0	0
4.37699	1.67619	0	0	0.805631	0.0626421	1.17189	0.404732	0	0
0.90093	1.43983	0	0	0.808056	0.0576550	1.29897	0.363161	0	0
2.97381	1.77806	0	0	0.851415	0.0612600	1.08314	0.419944	0	0
5.55020	1.91626	0	0	0.804669	0.0684851	0.97886	0.482967	0	0

------------------------------ ST=28 MON=2 MAT=7 ------------------------------

INT	SE	X10	SE10	X12	SE12	X14	SE14	X15	SE15
8.15142	2.58882	0	0	0.636252	0.0563124	0	0	0	0
8.15142	2.58882	0	0	0.636252	0.0563124	0	0	0	0
7.03262	2.94798	0	0	0.650558	0.0598927	0	0	0	0
9.83902	3.03121	0	0	0.570755	0.0696378	0	0	0	0
9.70438	2.94431	0	0	0.627882	0.0615230	0	0	0	0
2.08981	2.36275	0	0	0.815754	0.0581567	0	0	0	0

ST=28 MON=2 MAT=8

INT	SE	X10	SE10	X12	SE12	X14	SE14	X15	SE15
3.83502	1.57608	0	0	0.777891	0.0292679	0	0	0	0
3.83502	1.57608	0	0	0.777891	0.0292679	0	0	0	0
3.71271	1.63200	0	0	0.777323	0.0296603	0	0	0	0
4.00563	1.74975	0	0	0.771948	0.0333310	0	0	0	0
3.44976	1.91005	0	0	0.788294	0.0328827	0	0	0	0
3.92455	2.07276	0	0	0.791118	0.0428682	0	0	0	0

ST=28 MON=3 MAT=6

INT	SE	X10	SE10	X12	SE12	X14	SE14	X15	SE15
0.550459	0.78659	0	0	0.878188	0.0555312	0.50839	0.434868	0	0
0.067281	0.95707	0	0	0.884030	0.0836615	0.58407	0.505805	0	0
0.680705	1.03007	0	0	0.921660	0.0714025	0.08159	0.554432	0	0
0.451245	0.78094	0	0	0.866682	0.0535620	0.75943	0.445453	0	0
-0.051751	0.72000	0	0	0.818008	0.0500768	1.67900	0.455196	0	0
0.736885	0.87910	0	0	0.892617	0.0651781	0.31031	0.553108	0	0

ST=28 MON=3 MAT=7

INT	SE	X10	SE10	X12	SE12	X14	SE14	X15	SE15
0.32107	0.731469	0	0	0.910016	0.0288184	0	0	0	0
0.22630	0.880354	0	0	0.908147	0.0398984	0	0	0	0
0.34194	0.766447	0	0	0.912884	0.0290900	0	0	0	0
0.00884	0.767534	0	0	0.913483	0.0305734	0	0	0	0
0.61809	0.678363	0	0	0.904128	0.0274150	0	0	0	0
-0.15279	0.836740	0	0	0.923814	0.0319702	0	0	0	0

ST=28 MON=3 MAT=8

INT	SE	X10	SE10	X12	SE12	X14	SE14	X15	SE15
0.734063	0.317867	0	0	0.892966	0.00773884	0	0	0	0
0.560026	0.317250	0	0	0.898295	0.00771907	0	0	0	0
0.411240	0.307057	0	0	0.901523	0.00739653	0	0	0	0
0.325631	0.285243	0	0	0.905342	0.00707413	0	0	0	0
0.529004	0.319411	0	0	0.899211	0.00747453	0	0	0	0
0.434437	0.309639	0	0	0.897768	0.00730329	0	0	0	0

ST=28 MON=3 MAT=9

INT	SE	X10	SE10	X12	SE12	X14	SE14	X15	SE15
-0.32671	0.342732	0	0	0.979283	0.0093125	0	0	0	0
0.00829	0.429525	0	0	0.979299	0.0111846	0	0	0	0
-0.44207	0.428980	0	0	0.989183	0.0112697	0	0	0	0
-0.24382	0.405758	0	0	0.988278	0.0110358	0	0	0	0
-0.00778	0.405518	0	0	0.983029	0.0102385	0	0	0	0
-0.57083	0.377455	0	0	0.994040	0.0109955	0	0	0	0

ST=28 MON=4 MAT=9

INT	SE	X10	SE10	X12	SE12	X14	SE14	X15	SE15
-0.05496	0.473741	0	0	1.00213	0.0151895	0	0	0	0
-0.27335	0.629922	0	0	1.00607	0.0266679	0	0	0	0
0.25480	0.560985	0	0	0.99599	0.0159099	0	0	0	0
-0.29425	0.471682	0	0	1.00651	0.0147839	0	0	0	0
0.19913	0.487170	0	0	0.99871	0.0128303	0	0	0	0
-0.29005	0.685425	0	0	1.00524	0.0199339	0	0	0	0