

Testing the Forecasts of an Econometric Model

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Abstract

The Econometric Model of Oklahoma State University has been predicting various economic aggregates of Oklahoma since 1980. This research evaluates five major forecast measures of the model in the past decade. Two tests are used for this purpose: One, called "weak rationality," examines biases of those forecasts; another, called "strong rationality," explores the extent to which the model used all the information available at the time of forecasting. The results suggest that only one of the five forecast measures passed the "weak" test, and all passed the "strong" one.

Introduction

The Oklahoma State University (OSU) Econometric Model has been forecasting various economic measures of Oklahoma for the coming year, and has been annually reporting them in the *Oklahoma Economic Outlook* since 1980. This task is difficult and sometimes the forecasts are not very accurate. The forecasters employ data on historical development of the state in conjunction with the forecasts of the national economy as exogenous variables. The aim of their forecasts is to help many decision makers in the private and public sectors. In their annual pre-publication seminar a group of national, state, and industry observers are invited to discuss likely eco-

nomie outlook in the coming year. Then, they put their final inputs in the forecasts.

Usually no forecast hit the target, so that it is not equal to the realized value. Thus, the evaluation and judgment of forecasts turn into the question of how much they deviate from the actual values over time. The purposes of this research are to evaluate and test several major forecasts of the OSU econometric model in the past decade. Two types of tests are used for this purpose. The first, called "weak" rationality test, examines biases of those forecasts. The results of this investigation determine whether or not these forecasts pass the bias test, and, if they fail, by how much. They also show whether the model tends to overestimate or underestimate their forecasts, and by how much.

The second test explores and analyzes the extent to which the model incorporates all the information available at the time of forecasting. This latter test, called the rational or "strong" test, uses a model which includes the past forecasting errors and some other variables such as the growth of the population, as the information set available to the forecasters at the time of forecasts.

The OSU model annually reports several forecasts. However, this research investigates the rationality of the forecasts of only five major ones. They include Gross State Products (GSP), Civilian Labor Force (CLF), Non-Agricultural Employment (NAE), Personal Income (PI), and the Rate of Unemployment (UR).¹ These five are the major forecast measures of the

state economic activities and conditions, and are used more often by private and public sectors for their future plans.

Since its initial use, the OSU model has been evolving; and by using additional data, the parameters of the model have been reestimated. Although the forecasts and the rationality tests of different measures of the Oklahoma State University model were evaluated by different approaches, the rationality of these five major forecasts has never before been tested. The findings of this study suggest the forecasts of CLF, pass, and those of the GSP, NAE, PI, and UR do not pass the weak rationality test. However, the forecasts of all five measures pass the test of strong rationality.

The first section of this paper introduces the model which was utilized for this study. The second section explains the empirical findings of the weak and strong rationality tests. The final section provides a summary and conclusions. An appendix illustrates the forecast and actual values and their linear regression relationship, and the errors of each of these five measures.

The Model

Usually, forecasters predict their forecast values, $F_{t,f}$ or ex ante, based on a set of information variables, $S_{t,f}$ distinctively exogenous variables. Typically these relations are expressed as a single equation, or as a system of equations based on the values of exogenous variables, $S_{t,f}$ with different behavioral and iden-

tity relationships in the form of $F_{t-f} = g(S_{t-f})$. (1)

Here F_{t-f} is the forecast vector, and S_{t-f} is the information or exogenous vector.

Assuming each measure F_{t-f} is the forecast variable (ex ante), and A_t is the actual or realized variable (ex post), the weak rationality can be tested by the following regression equation as follows

$$A_t = \alpha_0 + \alpha_1 F_{t-f} + \mu_t \quad (2)$$

Where α_0 and α_1 are the parameters, and μ_t is the error term.

The weak rationality test is a joint null hypothesis of $\alpha_0 = 0$, and $\alpha_1 = 1$ in equation (2). That is, to pass this test it is required that the intercept of equation (2) to pass through the origin, i.e., $\alpha_0 = 0$, and the slope of the line to be equal to one, i.e., $\alpha_1 = 1$.²

The strong rationality test examines whether all the information available and known at the time of the forecast, t-f, was completely and efficiently used. To pass this test, it is required that no statistical association between the forecast errors and the information set be detected. That is, the information vector Z_{t-f} should not predict the forecast errors. Therefore, regressing the forecast errors, $A_t - F_{t-f}$, on the information vector, Z_{t-f} , as

$$[A_t - F_{t-f}] = \beta Z_{t-f} + V_t \quad (3)$$

the strong rationality inquiry is the test of a null hypothesis that the coefficient of the information vector, β , in the equation equals zero. In equation (3) V_t is the error term vector. In sum, the strong rationality test questions whether the abnormal errors are predictable by any information elements in the information set.

If the outcome indicates that these errors are predictable by the information available, one can conclude that information was not used efficiently. The information vector, Z_{t-f} includes a constant, past errors, a one-year lag of population and a one-year lag of four other variables.

Whereas the weak rationality test

is not a necessary condition for the strong rationality test, failing the strong rationality test does not necessarily indicate that the forecast is biased. It only suggests that some information was not used, or was used inefficiently.

Results

As a preliminary test, Table 1 presents the statistics of means, standard deviations, and coefficients of variation (standard deviation per mean) of forecast values (ex ante), actual (ex post), and forecast errors (actual - forecast) of the rate of growth of: Gross State Product, Civilian Labor Force, Non-agricultural Employment, Personal Income, and the rate

of Unemployment for the state.

Using 1981 to 1991 data, the outcome indicates that the means of the forecasts of GSP, NAE, and PI are higher than those of the actual data, whereas the means of forecasts of CLF, and UR are lower than those of the actual measures. These suggest that, on average, the forecasters overestimated GSP, NAE, PI, and underestimated CLF and UR.

Table 1 further provides the standard deviations of the forecasts and actual measures. These results indicate that the variation of the forecasts of GSP is higher and the variation of those of CLF, NAE, PI, and UR lower than those of the actual values.

Table 1

Means, Standard Deviations, and Coefficients of Variation of Actual, Forecasts, and the Errors for Five Different Economic Measures in Oklahoma

	GSP ^a (%)	CLF (%)	NAE (%)	PI (%)	UR (%)
Actual					
Mean	0.70	1.04	0.49	5.43	6.52
Std Dev	2.73	2.65	2.78	4.64	1.49
CV ^b	3.90	2.55	5.67	0.85	0.23
Forecasts:					
Mean	7.35	0.95	1.88	7.88	6.01
Std Dev.	3.70	1.57	1.97	3.74	1.24
CV	0.50	1.65	1.05	0.47	0.21
Forecast Errors: (Forecast-Actual)					
Mean	-6.64	0.09	-1.39	-2.45	0.50
Std Dev	3.65	2.14	3.03	3.58	1.63
CV	0.55	23.8	2.18	1.46	3.26

^a GSP = Gross State Products; CLF = Civilian Labor Force; NAE = Nonagricultural Employment; PI = Personal Income; UR = Rate of Unemployment

^b CV = Coefficient of Variation, and equals to Standard Deviation/Mean.

Figures 2, 4, 6, 8, and 10 in the Appendix display the forecast errors of the five measures. Table 1 shows also the means and standard deviations of their forecast errors. These findings demonstrate that the mean of the error for GSP was the highest, by 6.64 percent, and the mean of the CLF was the lowest, by 0.09 percent. The results further indicate that the standard deviation of the forecast error of the Gross State Product (GSP) of 3.65 was the highest and that of the rate of unemployment (UR) of 1.63 was the lowest.

As a general rule, whenever forecasters do not have sufficient information related to their forecasts, the error gets larger. In addition, the less information is available to the forecasters (i.e., more uncertainty), the higher the error of the forecast. If the value of the forecast exceeds that of the actual, the forecast is overestimated, and if the value of the actual exceeds that of the forecast, it is underestimated. Generally, the higher the uncertainty (due to less information), the higher the bias of the forecast downward, i.e., the forecast is underestimated.

This proposition is verified by the results which were reported earlier, that those measures with the highest (lowest) mean of the errors had the highest (lowest) variations. The proposition was further tested and confirmed by the resultant high and positive correlation coefficient of 0.76 between the means and the standard deviations of the errors of the forecasts.

Weak Rationality Tests

To investigate weak rationality, the parameters of equation (2) for the rate of growth of the forecast and actual data of five measures are estimated and the results are shown in Table 2, and Figures 1 to 10 in the appendix.³

The estimated parameters for the intercepts of the equations deviate from zero and range from -1.387 for

GSP to 4.375 for UR (see the corresponding Figures in the Appendix). Three of the intercepts have negative signs and the other two have positive signs. The positive intercepts imply underestimation and the negative intercepts suggest overestimation of the forecasts by the forecasters.

Table 2 also provides the estimated slopes for these five measures. The results suggest that the slopes deviate from one and range from high of .996 for CLF to low of 0.285 for GSP. The estimated slope of CLF is very close to one and does not reject the null hypothesis of $\alpha_1 = 1$, and thus suggesting a sound forecast for this measure.⁴

Each of the estimated slopes of the other four is less than one, suggesting that, as far as their slopes are concerned, the forecasters overestimated each of the four forecasts. The largest slope overestimation among these four was that of GSP, with a slope of 0.285, far below one (too flat, see Figure 1), and the smallest overestimation was that of PI, with the slope of 0.809. However, only the estimated slope of GSP rejects the null hypothesis of $\alpha_1 = 1$ only at 5 percent level of significance. The estimated slopes of the other four do not.

Table 2

Weak Rationality Tests for Five Different Economic Measures in Oklahoma

Variable	GSP ^a	CLF	NAE	PI	UR
α_0	-1.387 (0.8) ^b Overest	0.097 (0.1) Underest	-0.104 (0.1) Overest	-0.942 (0.4) Overest	4.375 (1.9) Underest
α_1	0.285 (3.2) [*] Overest	0.996 (0.01) Underest	0.315 (1.5) Overest	0.809 (0.6) Overest	0.357 (1.7) Overest
R ²	0.149	0.349	0.050	0.426	0.089
Adj R ²	0.055	0.276	-0.561	0.363	-0.013
DW	1.959	2.320	1.217	1.277	1.354

^a GSP = Gross State Products; CLF = Civilian Labor Force; NAE = Non-agricultural Employment; PI = Personal Income; UR = Rate of Unemployment.

^b 't' statistics are in parentheses. For α_0 the null hypothesis of $\alpha_0 = 0$, and for α_1 the null hypothesis of $\alpha_1 = 1$ is tested against the alternative hypotheses. The 't' ratios with * sign are significant at the level of 5 percent.

The results of the Durbin-Watson (DW) ratios of less than 2 for NAE, PI, and UR suggest that these measures had consecutive downward and consecutive upward predictions. On the

other hand, the DW test of more than 2 for CLF indicates that its forecasts had consecutive upward/downward values.

Table 3 presents the analysis of

variance and the "F" statistics of the joint null hypothesis of $\alpha_0 = 0$, and $\alpha_1 = 1$, as the weak rationality test for these five measures. Only the "F" ratio of CLF does not reject the null hypothesis at 5 or 1 percent level of significance ($F_{.05}[2, 9] = 4.26$, and $F_{.01}[2, 9] = 8.02$), and pass the weak test. But, the "F" ratios for the other four measures (GSP, NAE, PI, and UR) reject the null hypothesis, and therefore do not pass the test.

In sum, the resultant "F" statistics indicate that only the forecasts of CLF pass, and those of GSP, NAE, PI and UR do not pass the weak rationality test.

Strong Rationality Tests

Recall that this test questions whether the forecasters used all the information available to them at the time of forecasts completely and efficiently. Generally, the more related information the forecasters incorporate in their model, the closer the forecasts are to the corresponding actual values. Accordingly, if all in-

formation is used and used efficiently, the error of the forecast should not be statistically related to the information vector.

Using equation (3) the forecast error of each of the five measures is regressed on the lagged of the past error, μ_{-1} , lagged of the population growth, POP_{-1} , and lagged of the growth of other four measures. For example, the error of the GSP (DGSP) -- the difference between the growth of actual GSP (GSPA) and that of the forecasted GSP (GSPF) -- is regressed on its past error (μ_{-1}), and one year lagged actual civilian labor force (CLF_{-1}), actual non-agricultural employment (NAE_{-1}), actual personal income (PI_{-1}), actual rate of unemployment (UR_{-1}), and actual population (POP_{-1}).

Table 4 provides these results. The 't' statistics are shown in parenthesis; those with '*' signs are significant at 5 percent level. The estimated coefficients of variables with negative signs imply that the forecasters used them to improve their future prediction. On the other hand,

the variables with estimated coefficients of positive signs indicate that information about those variables caused larger forecast errors. Accordingly, the information about lagged population with negative signs was helpful in improving the forecasts of all five measures except for that of the rate of unemployment. On the other hand, the information about lagged personal income, and lagged unemployment rates did not improve the forecasts, as positive signs of their coefficients indicate. Therefore, higher past errors for these two variables resulted in higher current errors and adversely affected the forecasts.

As the findings for the past errors (μ_{-1}) indicate, only the sign of the CLF is negative. Those of the other four are positive. This implies that only in the case of the CLF did the past error of the forecast improve the current forecasts.

This line of argument is true for other variables in the information vector. For example, using equation (3) regressing the error of the CLF (DCLF) on the lagged GSP (GSP_{-1}) as an information variable (column 2 in Table 4) the estimated negative sign implies that the information about past GSP helped the forecasters to improve that forecast, and brought it closer to the actual values.

Finally, the null hypothesis that all the parameters of equation (3) for each of the five forecast errors are equal to zero, i.e., information vector $\beta = 0$, as the strong rationality test is measured by the "F" ratio, and shown in the last row of the table. These findings suggest that all of those five forecasts passed the strong rationality test, since none of their "F" ratios is higher than the critical value of $F_{.05}(6,3) = 8.94$. In other words, forecasters utilized the information available completely and efficiently for those five forecasts.⁵

Nevertheless, the strong rationality test is the test of the full use of the given information vector, such as the one which is used in this study, and

Table 3

Analysis of Variance: Test of Weak Rationality for Five Different Economic Measures in Oklahoma^a

	$(r-Ra)' [R(X'X)^{-1} R']^{-1} (r-Ra)b$	q	e'e	(n-K)	F	Results ^c
Variables						
GSP	238.1	2	63.26	9	837.1	R
CLF	0.110	2	45.67	9	0.279	NR
NAE	38.79	2	73.71	9	158.8	R
PI	70.41	2	123.30	9	482.3	R
UR	9.270	2	20.17	9	10.38	R

^a GSP = Gross State Products; CLF = Civilian Labor Force; NAE = Non-agricultural Employment; PI = Personal Income; UR = Rate of Unemployment.

^b See footnote 2.

^c R = Reject the null hypothesis, NR = Not reject the null hypothesis.

Table 4

Strong Rationality Tests for Five Different Economic Measures with Past Errors, μ_{-1} , and Lagged of Economic Variables and Population

Variables	DGSPa	DCLF	DNAE	DPI	DUR
Constant	38.24 (1.6) ^b	-14.19 (0.6)	-60.95 (2.8)*	-24.58 (0.9)	-2.05 (0.7)
μ_{-1}	1.55 (2.6)*	-1.27 (1.5)	2.36 (3.8)*	0.92 (0.8)	0.07 (0.1)
POP ₋₁	-0.89 (1.2)	-0.36 (0.4)	-0.67 (1.2)	-0.24 (0.3)	0.16 (0.4)
GSP ₋₁		-1.84 (1.1)	-1.61 (1.6)	-1.70 (1.2)	0.35 (0.4)
CLF ₋₁	1.77 (2.7)*		-0.11 (0.2)	0.20 (0.2)	-0.30 (0.6)
NAE ₋₁	1.03 (1.0)	0.92 (0.8)		2.55 (1.78)	-0.99 (1.5)
PI ₋₁	0.36 (0.3)	1.22 (0.9)	2.34 (2.1)		01.58 (0.8)
UR ₋₁	5.76 (1.8)	1.27 (0.5)	7.80 (2.9)*	3.63 (0.9)	
R ²	0.92	0.58	0.92	0.74	0.79
Adjusted R ²	0.75	-9.26	0.77	0.22	0.38
DW	2.55	2.47	2.40	1.93	2.64
F (a's = 0)	5.48	0.69	6.05	1.42	1.94

^a DGSP = GSPA-GSPF; DCLF = CLFA-CLFF; DNAE = NAEA-NAEF; DPI = PIA-PIF; DUR = URA-URF

^b 't' statistics are in parentheses. The 't' and 'F' ratios with * signs are significant at the level of 5 percent..

not all possible information. There may be other information variables which forecasters used and are not included in our information vector. This is clearly one flaw of the strong test.

Summary and Conclusions

The purpose of this study was to apply and analyze weak and strong rationality tests of forecasts of the rates of growth of Gross State Prod-

uct, Civilian Labor Force, Non-agricultural Employment, Personal Income, and the Rate of Unemployment estimated for the state of Oklahoma by the Oklahoma State University econometric model. The weak test examined whether, on the average, the forecasters have been on the target or not. That is the joint test of the null hypothesis of $\alpha_0 = 0$, and $\alpha_1 = 1$ in equation (2). The strong test inquired whether the forecasters used all the information available at the time of the forecasts, and if they utilized it efficiently. The joint test of the null hypothesis is that all parameters of the information vector, β , in equation (3) are equal to zero.

Using 1981 to 1991 forecasted and actual data the findings suggest that only the civilian labor force forecast passed the weak rationality test. The predictions of the other four did not pass that test. However, the forecasts of all five measures pass the strong rationality question, implying that the forecasters used all the information available and used it efficiently in their forecasts.

Notes

1. Initially the OSU model began forecasting GSP as an identity equation composing the activity of 10 industries. They include manufacturing, contract construction, wholesale and retail trade, finance, insurance and real estate, transportation, communication, public utilities, service, state, local, and federal government. The civilian labor force equation was depended on the lagged employment rate, state population, and a lagged civilian labor-force variable. The nonagricultural employment of the model was made of equations of employment of the industries which were used for the GSP, and their summation in the form of an identity equation. The personal income block of the

model consisted of five behavioral equations of nonfarm proprietors income, dividend, rent, and interest income, transfer payments, contribution to social insurance, wage and salary and other labor income. The unemployment rate equation for the state depends on the national unemployment rate, the state personal income variable, and the manufacturing sector's nominal wages in the state.

- This hypothesis is an 'F' statistic as follows

$$F = \frac{(r-R\alpha)' [R(XX)^{-1}R]'^{-1} (r-R\alpha)/q}{e'e / (n-k)}$$

Here r is the null hypothesis vector of $\alpha_0 = 0$, and $\alpha_1 = 1$, so that $r' = [0 \ 1]$, R is a 2 by 2 identity matrix, α is a vector with the estimated values of two parameters in the equation, $(XX)^{-1}$ is the inverse of variance-covariance, $e'e$ is the sum square error of the regression, q is the number of parameters tested on (α 's = 2), n is the number of observations, and k is the number of parameters in the equation (again α 's = 2).

- The rates of growth, instead of the levels of the variables are more appropriate and do not require adjustment for inflation.
- Recall that the null hypothesis for the slope is $H_0: \alpha_1 = 1$, against the alternative hypothesis of $H_1: \alpha_1 \neq 1$, instead of the conventional approach of $H_0: \alpha_1 = 0$ against the alternative hypothesis of $H_1: \alpha_1 \neq 0$.
- It should be pointed out that when variables with significant 't' statistics were eliminated from the equations in Table 4 the magnitudes of 'F' ratios changed. For DGSP equation, when μ_{-1} and CLF_{-1} dropped from the equation the 'F' ratio reduced to 2.75. Furthermore all 't' tests (in parenthesis) became insignificant as are shown below

$$DGSP = -7.12 + 0.56*NAE_{-1} - 0.55*PI_{-1} + 0.55*UR_{-1} - 0.732*POP_{-1} \quad (F1)$$

(0.26) (0.52) (0.48) (0.16) (0.71)

$R^2 = 0.69$, $Adj R^2 = 0.437$, $DW = 2.18$, $F(4, 5) = 2.75$.

When DGSP was regressed only on the past error, μ_{-1} and CLF_{-1} both of their 't' ratios became insignificant and "F" ratio of the equation declined, as are shown below. This suggests that the significant 't' ratios for DGSP in Table 4 for the two variables may be due to their interaction with other variables. Thus, these findings further confirm that the forecasts of the GSP passes the strong rationality test.

$$DGSP = -4.43 + 0.23*\mu_{-1} - 0.42*CLF_{-1} \quad (F2)$$

(1.4) (0.4) (0.6)

$R^2 = .25$, $Adj R^2 = 0.04$, $DW = 2.4$, $F(2,7) = 1.18$

The same treatment was given to DNAE and resulted the following equations.

$$DNAE = -4.23 - 1.58*\mu_{-1} - 0.99*CLF_{-1} + 0.93*PI_{-1} - 0.77*POP_{-1} \quad (F3)$$

(1.0) (0.9) (1.0) (0.8) (1.4)

$R^2 = .55$, $Adj R^2 = 0.19$, $DW = 2.4$, $F(4,5) = 1.54$

$$DNAE = -13.31 + 1.17*DNAE_{-1} + 2.04*UR_{-1} \quad (F4)$$

(3.6) (4.0) (3.4)

$R^2 = .70$, $Adj R^2 = 0.62$, $DW = 3.1$, $F(2,7) = 8.30$.

Note that while DNAE's forecast still passes the strong test, their results are not quite similar to those of the DGSP. The 't' ratios in equation (F3) are all insignificant, but those in equation (F4) are significant.

Appendix

Figure 1

Gross State Products: Forecasts, Actuals and Regression Line: 1981-91

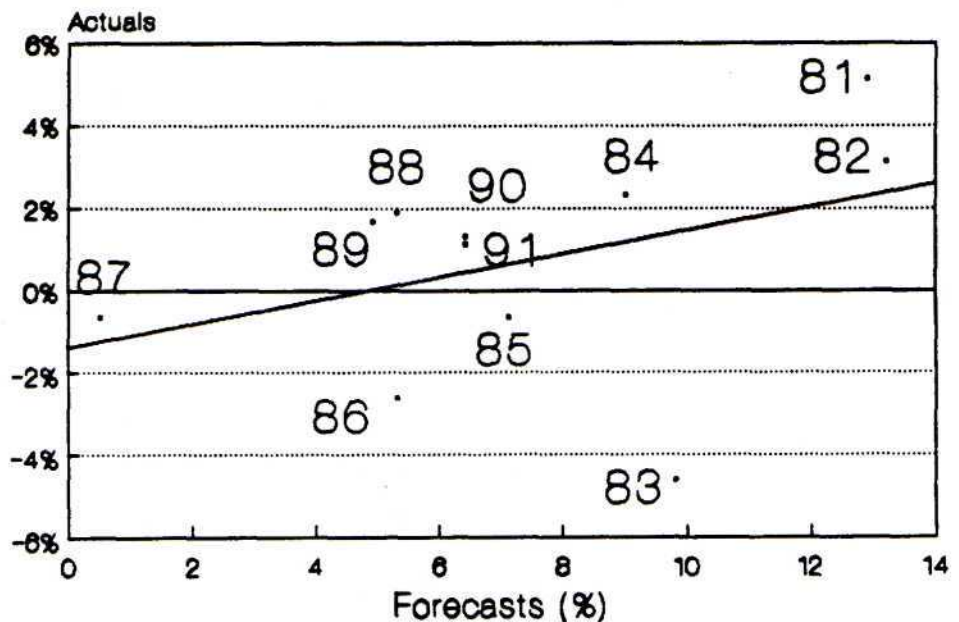


Figure 2

Forecast Errors: Growth of Gross State Products, 1981-199

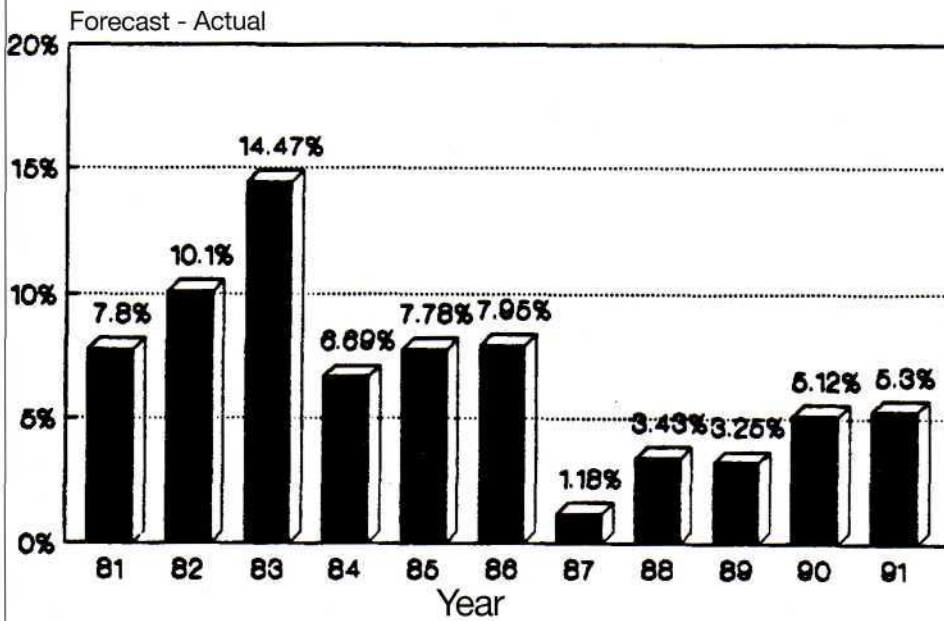


Figure 3

Civilian Labor Force: Forecasts, Actuals and Regression Line, 1981-91 *

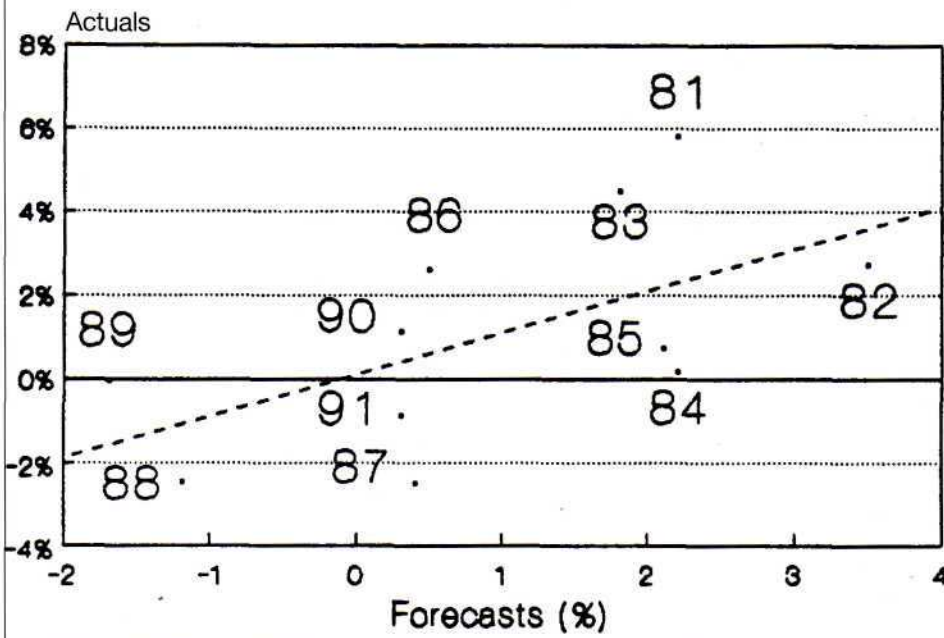


Figure 4

Forecast Errors: Growth of Civilian Labor Force, 1981-91

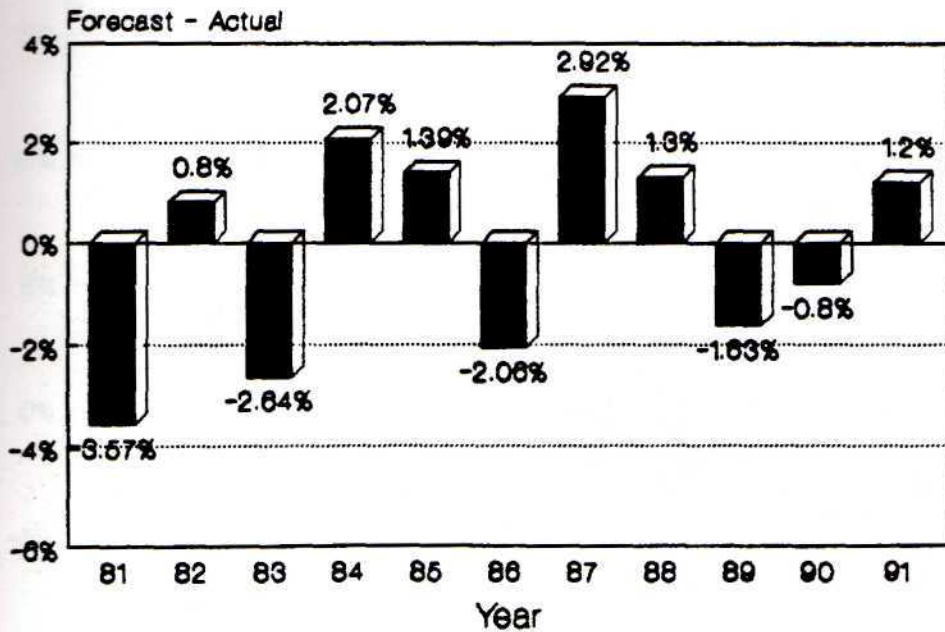


Figure 5

Nonagricultural Employment: Forecasts, Actuals and Regression Line, 1981-91

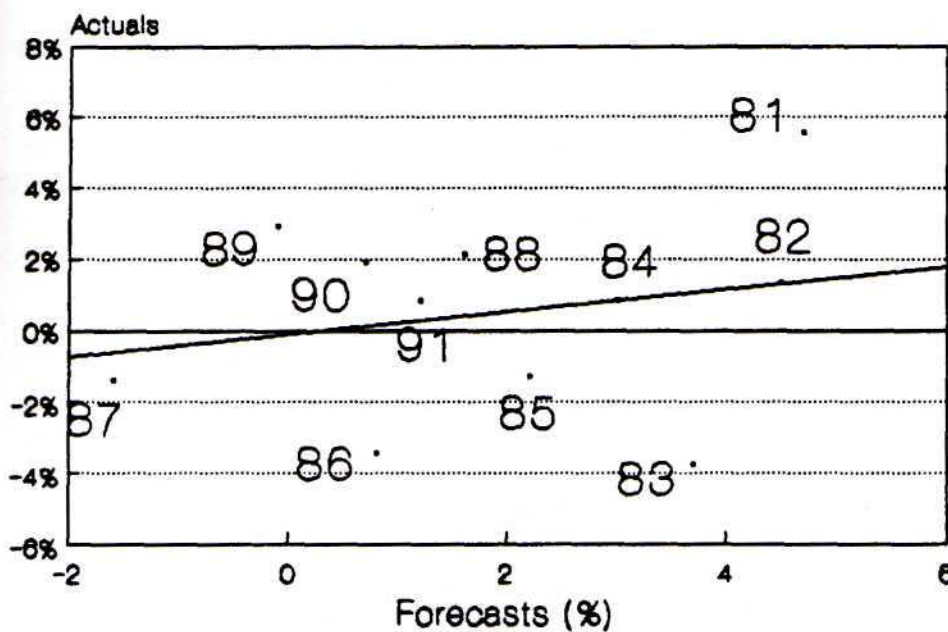


Figure 6

Forecast Errors: Growth of Nonagricultural Employment, 1981-91

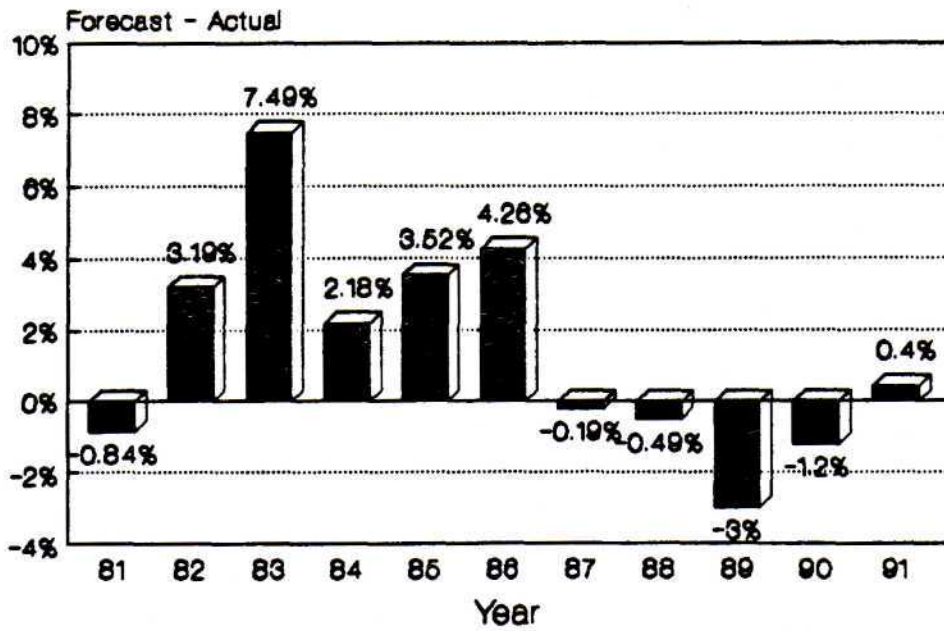


Figure 7

Personal Income: Forecasts, Actuals and Regression Line; 1981-91

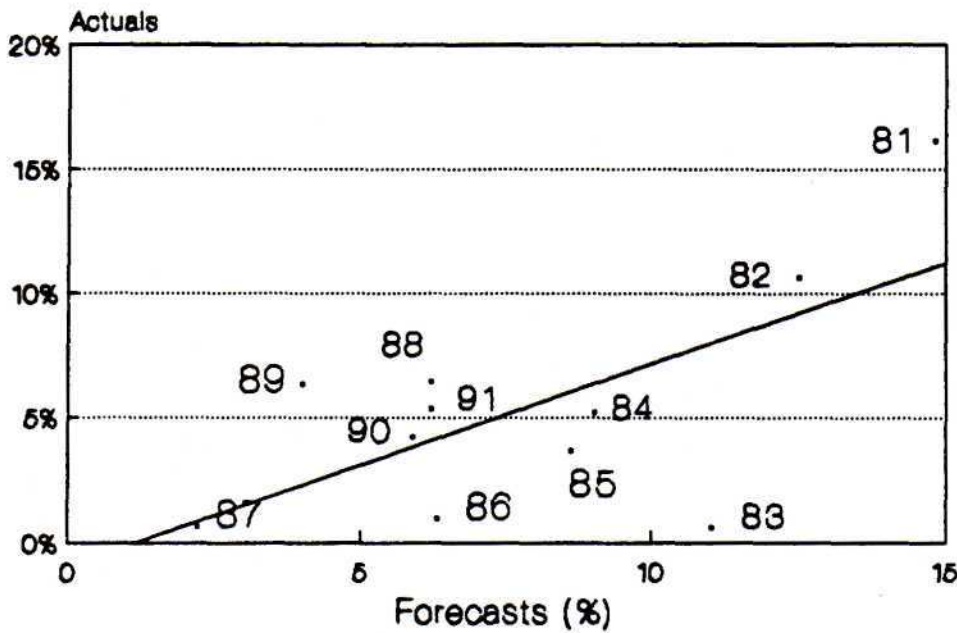


Figure 8

Forecast Errors: Growth of Personal Income, 1981-91

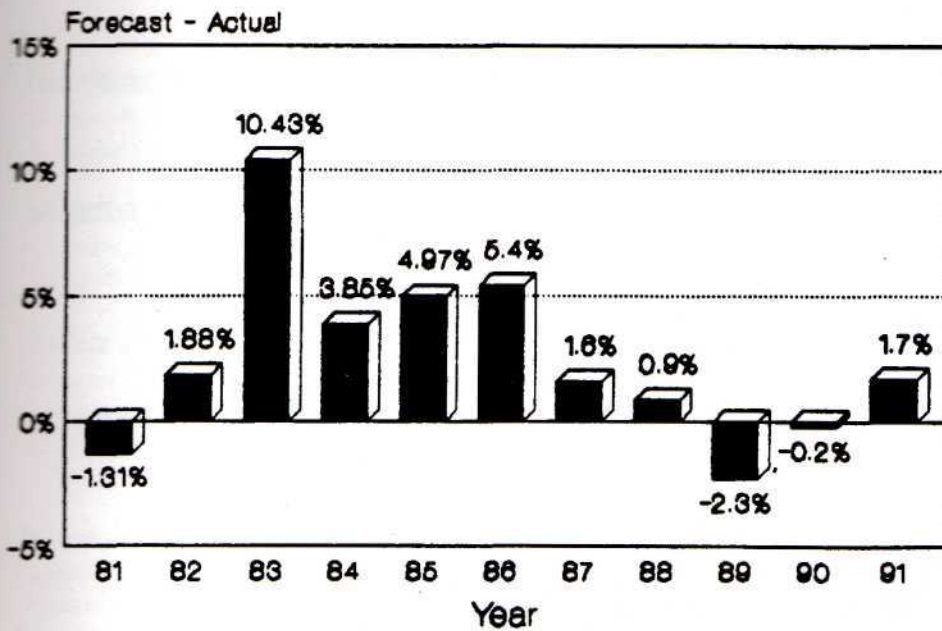


Figure 9

Rate of Unemployment: Forecasts, Actuals and Regression Line; 1981-91

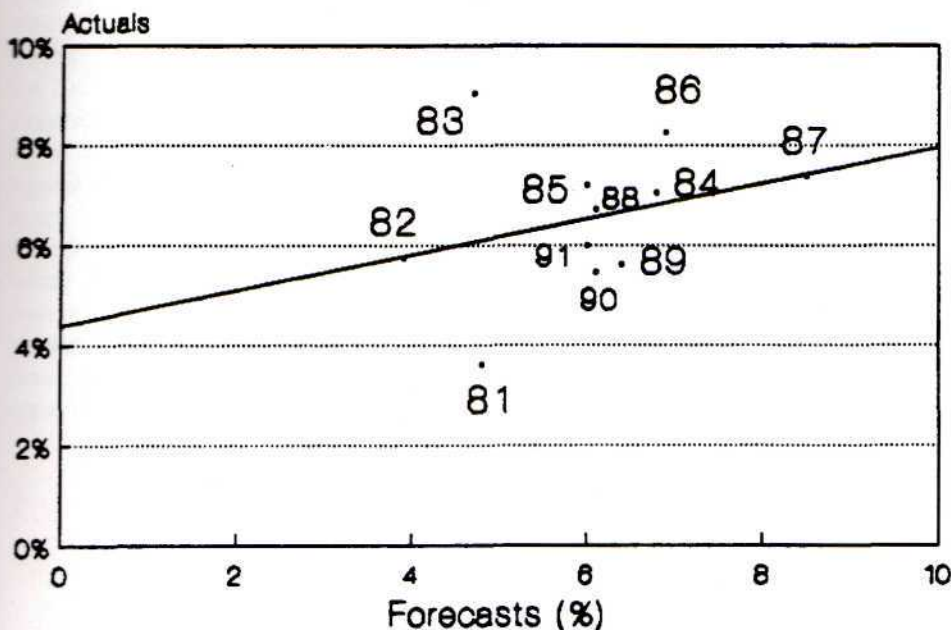
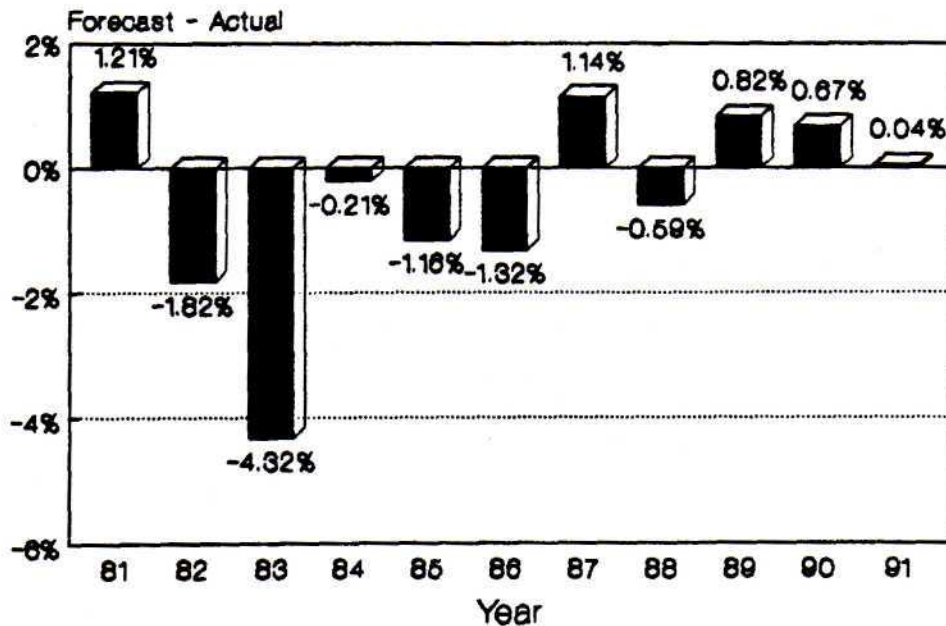


Figure 10

Forecast Errors: Rate of Unemployment, 1981-91



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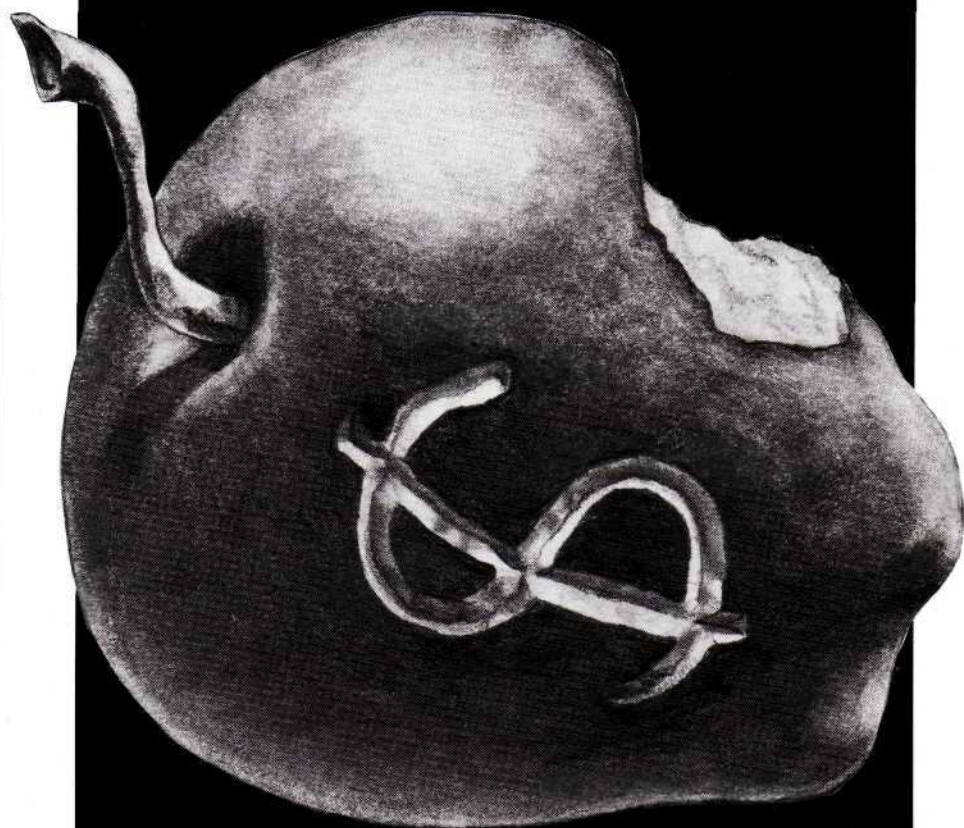
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