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Testing the Rationality of the National Bank of New Zealand's Survey Data

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Abstract

We test the rationality of the National Bank of New Zealand's survey data of inflation expectations. We cannot reject the null hypotheses of unbiasedness, efficiency, and orthogonality for a sample from 1985Q1 to 1996Q4. The survey's predictive power is better than those of the random walk and ARIMA models. During the period 1992q1-1996q1, where inflation is low and stable, the predictive power of an ARIMA model is better than that of the survey data. And the predictive power of the survey data is as good as that of the random walk model. These results are not inconsistent with rationality.

[1] I would like to thank Douglas Pearce, Dave Rae, Francisco Nadal De-Simone, and Leo Kripnner for their valuable comments.

1. Introduction

Expectation formation plays an important role in macroeconomic modelling. One way of incorporating rational expectations into modelling, and policy analysis is by using survey data provided that the data pass tests for rationality.

The National Bank of New Zealand's survey data of inflation expectations measure businessmen's expectations of the 12 months-ahead CPI inflation. At the beginning of each month, 1300 businessmen - of different businesses - are asked about their expectations of CPI inflation rate next year. The participation rate is 70 percent. The National Bank of New Zealand reports the average response after removing responses that exceed three standard deviations from the mean. The data have been published monthly since 1983 *without revisions*.

The primary purpose of this note is to test whether the National Bank of New Zealand's survey data are rational? Testing procedures for rationality of survey data that are discussed in the literature include testing for: (i) unbiasedness; (ii) efficiency; and (iii) orthogonality for the survey data (for example see, Eichenbaum, Hansen and Singleton (1988)). If the data pass these tests, they are said to be *weakly rational*. And if the data out-perform forecasts of other models such as ARIMA models then it is said that the survey data are *sufficiently rational*.[2] For the survey data to be *strictly rational*, they should pass tests for *strong rationality* (Granger and Newbold, 1973), where the survey's predictive power is better than that of a combination of various forecasts. In this paper, we test for *sufficient rationality*. Testing for *strong rationality* is not carried out at this stage.[3]

A secondary objective is to investigate the causal relationship between the survey data and past inflation rates.

It is shown that for the period 1985q1 to 1996q4:

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2 Pearce (1979, 1987) suggests that forecasts from ARIMA models can be considered rational under the assumption that economic agent's information set is limited to past history of inflation. So the survey data are rational if they perform as well as the ARIMA forecasts.

3 Testing for strong rationality requires a combination of different forecasts. Unfortunately, we do not have enough data to carry out the test at this stage.

(1) An OLS regression of annualised inflation on a constant, and the survey data is spurious because (i) the residuals are serially correlated, and the estimated variance-covariance matrix is inconsistent; and (ii) both the inflation rate and the survey data are non-stationary if one does not account for regime and trend shifts, which are apparent in the New Zealand data. Therefore, OLS is an inadequate method to test for the rationality of the survey data. For the same reasons, the regression of survey data on lagged inflation is misleading.

(2) The data pass tests for unbiasedness, orthogonality, and informational efficiency.

(3) We find that the inflation rate and the survey of inflation expectations are cointegrated.

(4) To account for serial correlation, simultaneity, and non-stationarity, we use *Two-Sided Dynamic Least Squares* (Phillips and Loretan, 1991) to estimate the long-run relationship between inflation and the survey data. We show that the model fits the data well, and the residuals are serially uncorrelated. Therefore, we can interpret the coefficient estimates of the regression, and carry out statistical tests.

(5) In terms of RMSE, the survey data predict inflation better than the random walk and ARIMA models in general.

(6) In terms of RMSE, an ARIMA model predicts inflation better than the survey data during periods of low and stable inflation.

(7) In terms of RMSE, the survey data predict inflation as good as the random walk model during periods of low and stable inflation.

(8) Past inflation does not Granger-cause the survey, but the survey data Granger-cause inflation.

We conclude that:

(1) The National Bank survey data are *sufficiently* rational.

(2) For estimation and calibration purposes using historical data for inflation from 1985q1 onward, survey data are a better proxy for inflation expectations than lagged inflation.

(3) As long as the inflation rate remains low and stable, the survey data offer little or no useful information about future inflation.

A model and the null hypotheses are presented in the next section. In section 3, we describe the estimation strategy, and discuss the results. In section 4, we compare the forecasting performance of the model with those of an ARIMA, and random walk models. We test for the absence of causality between the survey data and inflation in section 5. A conclusion is found in section 6.

2. The model and hypotheses

The model is given by the following linear relationship:

$$\Pi_t = a + b\ \Pi_t^e + u_t \qquad (1)$$

To test for rationality, we test:

(1) H_0^1 : *unbiasedness* : $E(u_{t,e}|\Pi_t^e)$ such that $a = 0$ and $b = 1$

(2) H_0^2 : *informational efficiency:* $E(u_t, u_{t-i,e}) \qquad \forall i \geq e$

We test that $a = 0$ and $b = 1$ jointly, and for the absence of serial correlation in the residuals of the model. If $a = 0$ and $b = 1$ then the survey data are unbiased predictors of the inflation rate.

(3) H_0^3: *weak orthogonality* : $E(u_t|\Pi_{t-i}) = 0 \qquad \forall i \geq 0.$

We regress the residuals on a constant and lagged inflation then test that the null hypothesis that the constant and all coefficients on lagged inflation are jointly equal to zero.

(4) H_0^4: *sufficient orthogonality* : $E(u_t|\Pi_{t-i}^e) = 0 \qquad \forall i \geq 0.$

The forecast error must not be correlated with past values of the survey data. Again, we regress the residuals u_t on a constant, and lagged values of the survey data then test that the null hypothesis that the constant and all coefficients on the lagged values of the survey data are jointly equal to zero.

(5) If the survey data pass all the tests above, it means that the survey data are *weakly rational*.

(6) If the data pass all the tests for weak rationality, we test for *sufficient rationality* by comparing the predictive power of the survey data with forecasts of ARIMA models.

3. Estimation and testing procedures

(1) Estimating equation (1) by OLS is inappropriate because, in general, the usual assumptions concerning the properties of the residuals are not met. Razzak (1994) provides evidence that the inflation rate is perhaps *non-stationary* but not a unit root process. If these two variables are non-stationary indeed, then OLS cannot be used for testing the data. We estimate equation (1) with a GST dummy variable.[4] We show that this regression is spurious.[5] The OLS results are reported in table (1). Inflation is defined as $\ln P_t - \ln P_{t-4}$, where P is the CPI. The sample is from 1985:1 to 1996:4. The coefficients a is *marginally* statistically different from zero at the 5 percent level, and b is statistically not different from unity. The F test for the joint hypothesis that $a = 0, b = 1$ indicates that we cannot reject the null hypothesis. However, the DW statistic is 0.77, and $\bar{R}^2$ is 0.89, which may be a case of a spurious regression. We also test the residuals for white-noise. The Kolmogrov-Smirnov test value is 0.4698, which exceeds the

[4] GST is a tax on goods and services. A 10 percent rate was introduced in 1986Q4, and an additional 2.5 percent in 1989Q3. We found the second dummy variable in 1989Q3 to be insignificant, therefore, it is dropped out of all regressions.

[5] Equation (1) does not account for changes in regime and trends. Usually, testing for unit root using testing procedures that do not account for mean and trend shifts like the ADF, and the Phillips-Perron tests results in a non-rejection of the unit root hypothesis. Razzak (1997) uses the Perron (1989) test that allows for a shift in the mean, and shows that the inflation rate and the survey data are not unit roots.

critical value at the 5 percent levels. Further, the residuals seem to be hetroskedastic as indicated by the test for ARCH(1) and ARCH(4).

(2) An easy way to deal with the non-stationarity is to re estimate equation (1) in first-differences.[6] Results are reported in table (2). The F-test indicates that the constant is insignificant, and b is statistically not different from unity. The residuals are serially uncorrelated, and homoskedastic. This regression shows that changes in the survey may be useful in explaining changes in the inflation rate.

To test H_0^3 we regress the residuals u_t *from the OLS regression (i.e.,* $\Pi_t - \hat{a} - \hat{b}\,\Pi_t^e - GST$ *)* on a constant and one lag of inflation.[7] We use two techniques. First, we use the OLS method. We then test the null hypothesis that the constant, and all the coefficients on lagged inflation are equal to zero jointly. The $F_{2,46}$ is 1.1553 with a P-value 0.3290, which indicates that we cannot reject the null hypothesis. Second, we estimate the model with OLS and a consistent variance-covariance matrix using the procedure suggested by Newey and West (1987). The $c^2_{.95,2}$ is 1.1975 with a P-value 0.5494 indicates that we cannot the reject the null hypothesis that the constant and the coefficient on lagged inflation are jointly equal to zero.

Similarly, we test H_0^4 by regressing the residuals on a constant and one lag of the survey data. We test the joint null hypothesis that the constant and the coefficients on all lags of the survey are zero. The $F_{2,46}$ is 0.0139 with a P-value 0.9861, and the $c^2_{.95,2}$ is 0.0133 with a P-value 0.9933, which indicate that we cannot reject the null hypothesis.

We can conclude that the survey data pass all four tests, and they are *weakly rational.*

To deal with the problems of serial correlation, simultaneity, non-stationarity, and to estimate a consistent covariance matrix,[8] one can use the *Two-Sided Dynamic Least Squares* of Phillips and Loretan (1991) to

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[6] If the data are not unit root but non-stationary (eg, fractionally integrated) then first-differencing the data is actually an over-differencing.

[7] We start with four lags and test backward using an F test.

[8] For discussion see Brown and Maital (1981), and Newey and West (1987).

estimate equation (1). Before estimation, we test the null hypothesis that the inflation rate and the survey data are not cointegrated. Two procedures are used.

First, we use the Engle-Granger (1987) method to test the null hypothesis. The results are reported in table (3). We regress the inflation rate on a constant, the survey data, and GST dummy variable. We then test the null hypothesis that the residuals from this regression are unit roots using the Phillips-Perron Z test.[9] Results indicate that at the 5 percent level, the null hypothesis of no cointegration between inflation and the National Bank survey data may be rejected. The results should be interpreted with care because the data are potentially subject to problems such as small sample size, short span, structural breaks, and most importantly, the residuals are hetroskedastic as shown in table (1). The null hypothesis that the residuals contain a unit root is rejected at the 5 percent level.

Second, we use the Gregory-Hansen (1996) method. This method allows for a regime and trend shifts, which might be more appropriate to testing New Zealand data. However, the method cannot overcome small sample problems. The procedure is given by:

$$\Pi_t = a_1 + a_2 D_t + a_3 t + a_4 t\ D_t + a_5\ \Pi_t^e + a_6 \Pi_t^e\ D_t + a_7\ t.\Pi_t^e + a_8\ GSTD + e_t \quad (2)$$

D=1 from 1985:1 to 1991:4 and zero elsewhere.[10]

$$\Delta\, e_t = a + r\ e_{t-1} + \sum_{i=1}^{k} d_i\ \Delta\, e_{t-i} + v_t \quad (3)$$ [11]

H_0: $r = 0$

Results are reported in table (4). Although, the results indicate that we can reject the null hypothesis that the inflation rate is not cointegrated with the survey data; the rejection is, however, marginal. The results of

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9 The test accounts for heteroskedasticity in the residuals from the first stage regression. We start with four lags of the differenced residuals, and found one lag only to be significant.

10 We search for different dummy variables in the period 1989q1 to 1994q4. We find that this dummy to be the most significant, and the residuals of the model are white-noise.

11 We start with 4 lags, test backward using F-tests, and eliminate unnecessary lags. We found k=2 to be optimal.

these two tests do not seem to be providing an unambiguous rejection of the null hypothesis. Nevertheless, we will assume that the two variables are cointegrated so we can use the Phillips-Loretan procedure to make inference about the magnitudes of a *and* b.

Now, we use the Phillips-Loretan (1991) *Two-Sided Dynamic Least Squares* to estimate equation (1). The model is given by:

$$\Pi_t = a + b \ \Pi_t^e + \sum_{i=-k}^{k} d_i \ \Delta \Pi_{t-i}^e + r \ (\Pi_{t-1} - a - b \ \Pi_{t-1}^e) + v_t \quad (4)$$ [12]

Results are reported in table (5).[13] The parameter b is not significantly different from unity. Also, the joint test that a =0, and b =1 cannot be rejected, which implies that we cannot reject H_0^1. The DW statistic indicates that the residuals are serially uncorrelated. Further, the Kolmogrov-Simrnov statistic indicates that we cannot reject the null hypothesis that v_t are white noise at the 1 percent level. Thus, we cannot reject H_0^2. We then test for the absence of ARCH (1) and ARCH (4). We cannot reject the null hypotheses that there are no ARCH (1) and ARCH (4) in the data. All the results above support the unbiasedness hypothesis.

4. Forecasting

Finally, we compare the predictive power of the survey data with the forecasts from a random walk model, and an ARIMA model.

We estimate ARIMA and random-walk models from 1961q1 to 1984q1. The inflation rate is defined as $\ln P_t - \ln P_{t-1}$ (ie, quarterly inflation rate). The best model is chosen on the basis of (i) a grid search surrounding the final parameter estimates; and (ii) the residuals being serially uncorrelated. An ARIMA (1,1,1) model is chosen. We then forecast inflation for 1985q1-1985q4. The one-year-ahead forecast is the sum of the four quarters forecasts. Then we re-estimate the ARIMA, and the random walk models sequentially by adding one observation at the time,

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[12] We set k equal to one. With k=1, the residuals are serially uncorrelated. With k > 1, we risk over-fitting, and possibly introduce size distortion to the tests.

[13] A GST dummy is also included in the regression.

and forecast one-year-a head inflation every time. So each forecast from the ARIMA and the random-walk models is comparable with the survey data, which represent one-year-ahead forecasts for the inflation rate.

We compare the *Root-Mean Square Errors* (RMSE) for the survey, the ARIMA, and the random-walk model's forecasts in the full sample 1985q1 to 1996q1, in a sub-sample from 1985q1 to 1988q4, in a sub-sample from 1989q1 to 1991q4, and in a sub-sample from 1992:1 to 1996:1. The first sub-sample is the period of high and volatile inflation. The period 1985 to 1988 is the period before the Reserve Bank Act of.1989. The period 1992q1 to 1996q1 is characterised by low and stable inflation. The results are reported in table (6). We compare RMSE for each sub-sample *across the rows* in table (6). The survey's RMSE is smaller than that of the ARIMA (1,1,1) and the random-walk models in the full sample, and in the first and second sub-samples. The RMSE of the ARIMA model is smaller than that of the survey data in the last sub-sample. This implies that agents make more accurate forecasts in periods of low and stable inflation. These results also suggest that in periods of low and stable inflation, ARIMA models are sufficient forecasting tools. This says that for economic agents, the cost of investing in sophisticated forecasting models exceeds the benefits when inflation is low and stable, which is not inconsistent with rational expectations.

Figures 1, 2, 3, and 4 are scatter plots of inflation and the survey data for the full sample, and the sub-periods 1985q1 to 1988q4, 1989q1 to 1991q4, and 1992q4 to 1996q4. Clearly, the survey's ability to forecast inflation deteriorated -relative to the ARIMA forecasts - as inflation became low and stable. The inflation rate, the survey data, ARIMA and random walk forecasts are plotted in figures 5, 6, and 7.

5. Causality

What can we say about the relationship between the survey data and past inflation? To answer this question we use the Granger causality test.[14] We use two procedures. First, is a VAR in differences. Results are reported in table (7). In this test, the inflation rate and the survey data are assumed to be *not* cointegrtaed. The F-tests indicate that we can reject the null hypothesis that the survey data do not Granger-cause inflation,

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[14] The tests are used for a sample from 1985q1 to 1996q4.

but cannot reject the null hypothesis that the inflation rate does not Granger-cause the survey data. Therefore, causality runs in one direction from the survey data to the inflation rate.

In a second test for causality, I maintain the assumption that the inflation rate and the survey data are cointegrated, so we estimate a *vector error-correction model.*

$$\Delta \Pi_t = a_1 + A(L)\, b_i\, \Delta \Pi_{t-i} + A(L)\, d_i\, \Delta \Pi^e_{t-i} + r\,(\Pi_{t-1} - \Pi^e_{t-1}) + x_{1t} \quad (5)$$

$$\Delta \Pi^e_t = a_2 + A(L)\, q_i\, \Delta \Pi_{t-i} + A(L)\, h_i\, \Delta \Pi^e_{t-i} + r(\Pi_{t-1} - \Pi^e_{t-1}) + x_{2t} \quad (6)$$

Results are reported in table (8). We test $H_0: d_i's = 0, r = 0$, and $H_0: q_i's = 0, r = 0$. The F-tests indicate that we can reject the null hypothesis that the survey data do not granger-cause the inflation rate, but we cannot reject the null hypothesis that the inflation rate does not Granger-cause the survey data. Again, causality runs in one direction from the survey data to the inflation rate. These results indicate that survey respondents have relevant knowledge about future inflation beyond that contained in past inflation. The survey data may contain the information in past inflation.

6. Conclusions

(1) The survey data pass tests for unbiasedness, efficiency, and orthogonality.

(2) The survey's predictive power is better than those of the random walk and ARIMA models for the full sample from 1985q1 to 1996q1.

(3) In general, this evidence suggest that the survey data are *sufficiently rational*.

(4) The predictive power of the survey deteriorates as the inflation rate becomes low and stable. In terms of RMSE, an ARIMA(1,1,1) model

seems to predict inflation better than the survey data during the period 1992q1-1996q1. Also, the predictive power of the survey is as low as that of the random walk model.

(5) For model estimation and calibration using historical data for inflation from 1985q1 onward, researchers may find it useful to use the survey data instead of lagged inflation as a proxy for inflation expectations. For example, the researcher who is interested in fitting a Phillips curve may use the survey data as a proxy for inflation expectations rather than lagged inflation.

(6) As long as the inflation rate remains low and stable, the survey data offer little or no useful information about future inflation. Therefore, in forecasting inflation using information from the period 1992 onward, the survey can have a weight of zero.

(7) Lagged inflation is not a significant determinant of the survey data. Granger causality runs from the survey to the inflation rate only, which indicates that survey respondents have relevant knowledge about future inflation beyond that contained in past inflation.

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Table 1
OLS Estimates
Sample 1985:1 to 1996:4

Parameter	Coefficient	t-ratio	P-value
a	-0.84	-2.01*	0.0502
b	0.98	19.07*	0.0001
GSTD	3.97	2.32*	0.0248
$F_{1,45}$ H_0: $a=0$, $b=1$	4.0473 (0.0502)		
$\bar{R}^2$	0.89		
DW	0.77		
Kolmogrov-Smirnov[a]	0.4698*		
ARCH (1)	20.40* (0.0001)		
ARCH(4)	27.03* (0.0001)		

Asterisk means significant at the 1 percent level.

GSTD: Is a dummy variable that takes a value of 1 in 1986Q4, and zero elsewhere.

a: The critical values at the 1 and 5 percent levels are 0.2835 and 0.3398 respectively.

Table 2
OLS Estimates In First-Differences
Sample 1985:1 to 1996:4

Parameter	Coefficient	t-ratio	P-value
a	-0.035	-0.16	0.8693
b	0.93	3.24*	0.0022
GSTD	5.57	3.92*	0.0002
$F_{1,45}$ H_0: a =0, b =1	0.0267 (0.9736)		
$\bar{R}^2$	0.40		
DW	1.90		
Kolmogrov-Smirnov[a]	0.0912		
ARCH (1)	0.0003 (0.9884)		
ARCH(4)	0.0883 (0.9990)		

Asterisk means significant at the 1 percent level.

GSTD: Is a dummy variable that takes a value of 1 in 1986Q4, and zero elsewhere.

a: The critical values at the 1 and 5 percent levels are 0.2835 and 0.3398 respectively.

Table 3
The Engle-Granger Test

$$\Pi_t = a + b\,\Pi_t^e + GSTD + u_t$$

$$\Delta u_t = a' + r\,u_{t-1} + \sum_{i=1}^{k} d_i\,\Delta u_{t-i} + x_t$$

$$H_0 = r = 0$$

t-test	Z-test
-3.4481*	-19.724*

Asterisk means significant at the 5 percent level.

The 5 percent critical value for the ADF is -2.86, and the 5 percent critical value for the Z test is -14.1.

Table 4
The Gregory-Hansen Test for "no" Cointegration

$$\Pi_t = a_1 + a_2 D_{tt} + a_3 t + a_4 t D_{tt} + a_5 \Pi_t^e + a_6 \Pi_t^e D_{tt} + a_7 \, t \, \Pi_t^e + a_8 \, GSTD + e_t$$

D=1 from 1985:1 to 1991:4 and zero elsewhere

$$\Delta e_t = a + r \, e_{t-1} + \sum_{i=1}^{k} d_i \, \Delta e_{t-i} + v_t$$

H_0: r =0

Parameter	Coefficient	t-value	p-value
r	-1.06	-5.56*	0.0001
$\bar{R}^2$	0.41		
DW	2.10		

Two lags are found to be significant so k is set equal to 2. The critical value at the 5 percent level is -5.50.

Asterisk means significant at the 5 percent level.

Table 5
Two-Sided Dynamic Least Squares Estimate
(Phillips-Loretan, 1991)
Sample 1985:1 to 1996:4

Parameter	Coefficient	t-ratio	P-value
a	-0.20	-0.37	0.7051
b	0.98	10.22*	0.0001
Wald H_0: a =0, b =1		0.36(0.8336)[a]	
DW		2.01	
Kolmogrov-Smirnov		0.1350[b]	
ARCH (1)		0.0050 (0.9433)[c]	
ARCH(4)		2.4481 (0.6539)[d]	

a: This distributed chi-squared with 2 degrees of freedom.
b: The critical values at the 1 and 5 percent levels are 0.2835 and 0.3398 respectively.
c: This is distributed chi-squared with one degree of freedom.
d: This is distributed chi-squared with four degrees of freedom.
Asterisk means significant at the 1 percent level.

Table 6
RMSE for the Survey, ARIMA (1,1,1), and Random-Walk Models

Sample Forecasts	Survey	ARIMA (1,1,1)	Random-Walk
1985q1-1996q1	1.95595	3.20103	3.48583
1985q1-1988q2	2.63605	4.90572	5.27075
1989q1-1991q4	1.69549	2.32352	2.50036
1992q1-1996q1	1.24811	0.81364	1.26678

Table 7
Granger-causality tests

Null Hypothesis	F-test	P-value
H_0: Survey $\nrightarrow$ Inflation	7.12*	0.0001
H_0: Inflation $\nrightarrow$ Survey	2.56	0.0530

F-tests are $F_{4,39.}$

Asterisk means significant at the 1 percent level.

Table 8
Granger-causality tests
Vector Error Correction Model

$$\Delta\,\Pi_t = a_1 + A(L)\, b_i\, \Delta\,\Pi_{t-i} + A(L)\, d_i\, \Delta\,\Pi^e_{t-i} + r\,(\Pi_{t-1} - \Pi^e_{t-1}) + x_{1t}$$
$$\Delta\,\Pi^e_t = a_2 + A(L)\, q_i\, \Delta\,\Pi_{t-i} + A(L)\, h_i\, \Delta\,\Pi^e_{t-i} + r(\Pi_{t-1} - \Pi^e_{t-1}) + x_{2t}$$

$H_0: d_i's = 0,\ r = 0$**, and** $H_0: q_i's = 0,\ r = 0$**.**

Null Hypothesis	F-test	P-value
H_0: Survey $\nrightarrow$ Inflation	7.37*	0.0008
H_0: Inflation $\nrightarrow$ Survey	2.45	0.0503

F-tests are $F_{5,38}$.

Asterisk means significant at the 1 percent level.

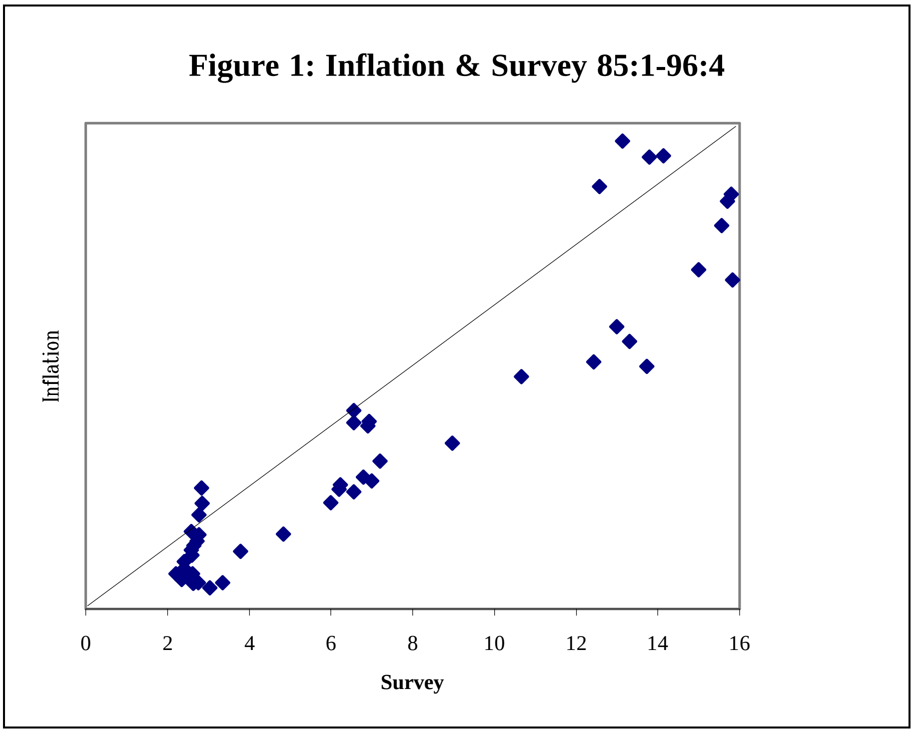
Figure 1: Inflation & Survey 85:1-96:4
Inflation
0
2
4
6
8
10
12
14
16
Survey

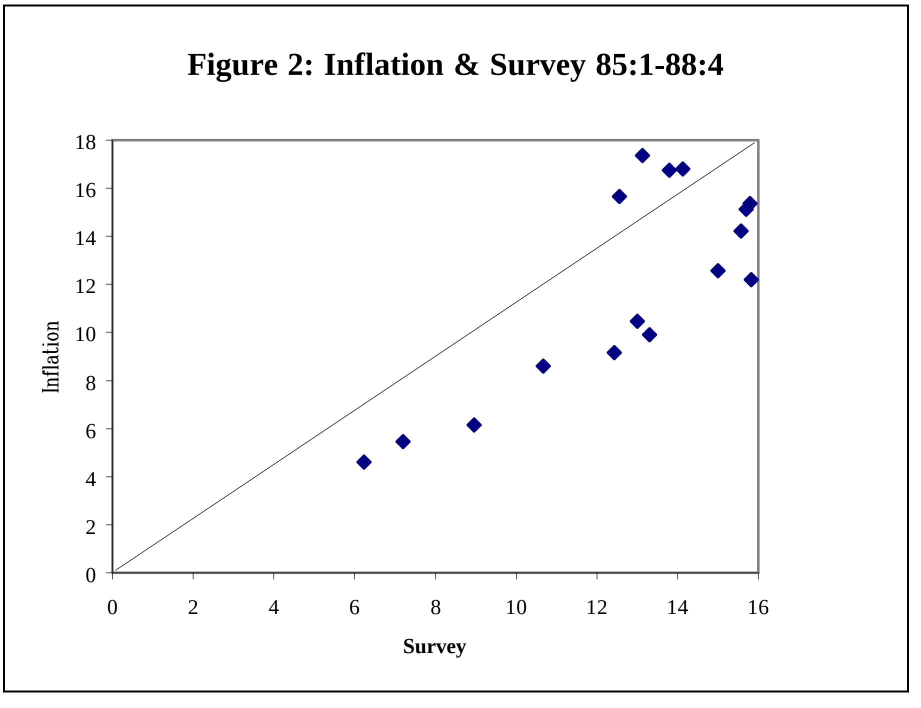
Figure 2: Inflation & Survey 85:1-88:4
18
16
14
12
10
8
6
4
2
0
Inflation
0
2
4
6
8
10
12
14
16
Survey

Figure 3: Inflation & Survey 89:1-91:4

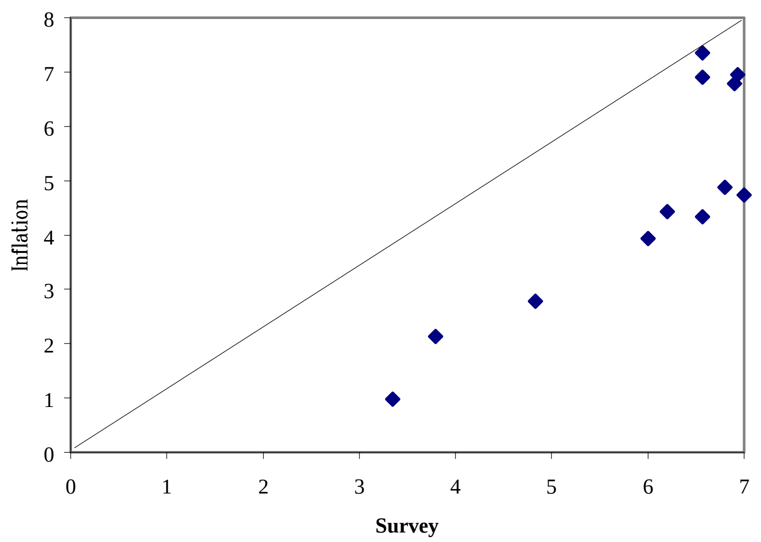

Figure 4: Inflation & Survey 92:1-96:4

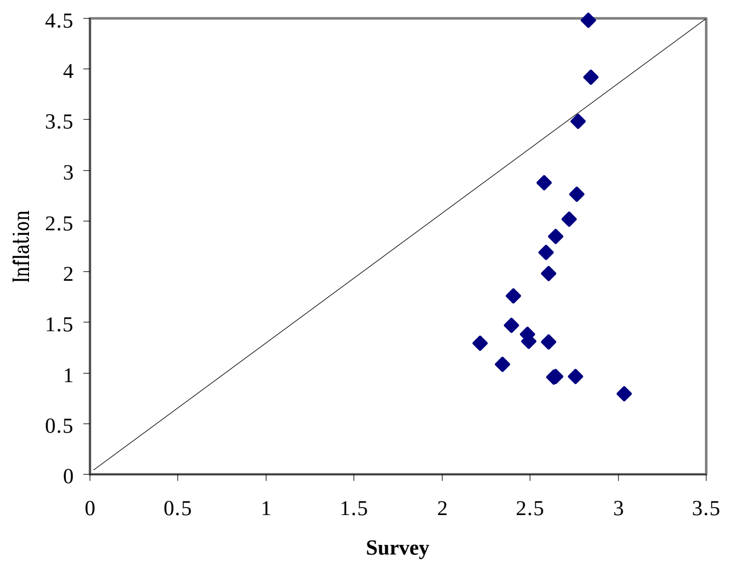

Figure 5: Inflation & the Survey of Expectations

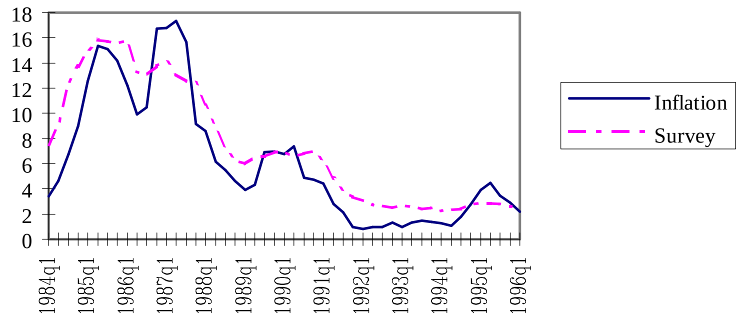

Figure 6: Inflation & the ARIMA Forecasts

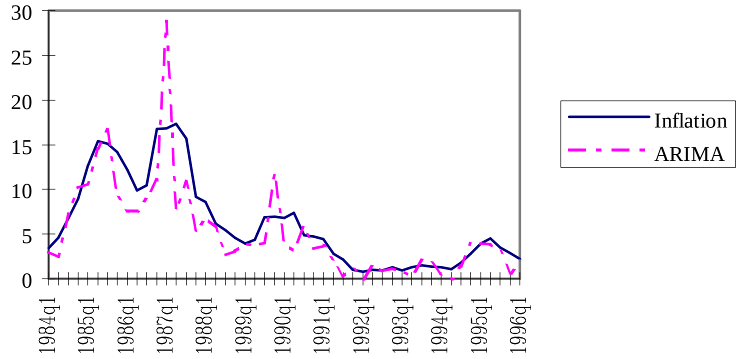

Figure 7: Inflation & the Random Walk Forecasts