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South African Reserve Bank Working Paper

The formation of inflation expectations in South Africa

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Abstract

A key factor in the inflation-targeting regime is the psychological process by which individuals and firms form their expectations of future inflation. From a monetary policy perspective, it is important to analyse this process, since under full rationality, only unexpected changes in inflation will affect real variables. In this paper, data from both the Bureau for Economic Research's Inflation Expectations Survey and the Reuters Inflation Expectations Survey are evaluated, over different forecasting horizons to asses the characteristics of expectations formation across different economic groups in the South African economy. The results do not provide strong evidence to indicate that South African economic agents are exclusively rational or exclusively adaptive in formulating their inflation expectations. However, it appears that individuals employ some form of non-homogenous learning by combining some features of rationality with adaptive behaviour in order to minimise their forecast errors over time, subject to their respective available resources.

JEL classification: D83, D84, E31, E52

Keywords: Inflation expectations, rational expectations, adaptive expectations, bounded rationality, inflation expectations surveys

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1 Introduction

The primary objective of most central banks is to achieve and maintain a stable and low rate of inflation over the medium to long term. Many central banks have adopted an implicit or explicit inflation-targeting framework to manage this process. A key factor in the inflation-targeting regime is the psychological process by which individuals and firms form their expectations of future inflation.

The role of expected inflation in macroeconomic theory has received increased attention, ranging from the expectations-augmented Phillips curve relationship (which suggests that actual price changes are driven mainly by aggregated expectations of its future change) to the recent bounded rationality and, in particular, learning expectations concepts (see e.g. Sargent, 1993 and Evans and Honkapohja, 2001). The relevance for monetary policy of analysing the rationality of agents follows from the view that under full rationality, only unexpected changes in inflation will affect real variables.

Various empirical procedures that test for the nature of the expectations formation process in survey data are described in the literature. Tests for rational expectations include tests for unbiasedness, efficiency and orthogonality of the data (see Razzak, 1997). If the data pass these tests, then expectations may be classified as *weakly rational*. Secondly, if the data outperform forecasts of other models, such as ARMA models, then expectations may be classified as *sufficiently rational* (see Pearce, 1979, 1987). Thirdly, if the predictive power of survey data outperforms a combination of various forecasts, then expectations may be classified as *strictly rational* (see Granger and Newbold, 1973). In the literature, there are also tests available to analyse the extent of adaptive expectations formation for survey data (see Figlewski and Wachtel, 1981).

Inflation expectations are difficult to measure, as they are not directly observable. Internationally, the results from regular inflation expectations surveys are often used as a proxy for inflation expectations. Examples of these include the Livingston Survey of Professional Economists for the United States, the Consumer Survey for the

European Union and the Conference Board of Canada that produces survey data on Canadian inflation expectations. In South Africa, the Reuters Inflation Expectations (RIE) Survey and the Bureau of Economic Research (BER) of the University of Stellenbosch Inflation Expectations Survey produce survey data on South African inflation expectations[1,2.]

When inflation expectation data are scarce or unreliable, analysts often use other macroeconomic variables to proxy this entity. Examples of these include using past values of actual inflation, i.e. backward-looking or adaptive inflation expectations, or the rate of change in some version of a consumption expenditure deflator, often the one for durable goods. Another proxy frequently used is the difference between the yield on inflation-linked bonds and their non-inflation linked counterparts, for instance the difference between the R157 and the R189 bond yields in the South African case. Unfortunately, inflation-linked bonds were only issued in South Africa from 2000 so that this proxy would be subject to degrees of freedom constraints.

In this analysis, data from both the BER Inflation Expectations Survey and the RIE Survey will be evaluated over different forecasting horizons to assess the characteristics of expectations formation across different economic agents in the economy. From these test results, it should be possible to infer the most likely inflation expectations formation process by economic agents in South Africa. It should be noted from the onset that due to the small sample of available data, the results may display small sample bias. Section 2 will describe different theories of inflation expectations formation and Section 3 will provide a brief overview of inflation expectations formation in South Africa across different economic agents in the economy. In Section 4 both the RIE and BER Survey data are tested for rationality.

[1] The RIE Survey is conducted monthly and covers approximately 14 respondents who are mainly market analysts. Monthly data from this survey are available from December 1999. In this survey, respondents are asked on a monthly basis what rate of inflation they expect will realise in the current as well as the following six quarters and what annual rate of inflation they expect for the current year and the following two years.

[2] The BER Inflation Expectations Survey is available at a quarterly frequency from the first quarter of 2000. This survey covers four groups of respondents namely from the business sector (n=375), the financial sector (n=15), the trade union sector (n=12) and households (n=1898). (These sample sizes (n) are based on the number of respondents in the survey conducted in the first quarter of 2003.) This survey is similar to the Livingston survey conducted in the United States. For additional information on the latter survey see Roberts (1998) and on the former see Kershoff and Smit (2002).

Section 5 tests both sets of survey data for adaptive expectations, which is then followed by some concluding remarks.

2 Inflation expectations

2.1 Theories of inflation expectations formation

2.1.1 Adaptive expectations

In the 1930s Irving Fischer developed the notion of adaptive expectations, which suggests that agents do not fully understand the functioning of the economy, but in every time period, agents adjust their expectation of inflation in accordance with the previous forecast error they had made (i.e. the difference between their expectation of inflation and the actual outcome). The adaptive expectations rule is specified as:

$$\pi_t^e = \pi_{t-1}^e + \lambda(\pi_{t-1} - \pi_{t-1}^e) \qquad (2.1)$$

where π_t^e represents the expectation of the current inflation rate, π_{t-1}^e is the expectation of the inflation rate in the previous period, π_{t-1} is the actual inflation rate in the previous period and λ represents the adaptive coefficient.

A critique of adaptive expectations was that according to the expectation formation rule, agents would consistently underestimate inflation in periods of rising inflation and overestimate it in periods of disinflation.

2.1.2 Rational expectations

Criticism of the backward-looking approach to the modelling of expectations (and macroeconomic modelling in general) formed the basis of the rational expectations revolution in economics, pioneered by Muth (1961) and eventually Lucas (1976). According to rational expectations theory, individual agents are assumed to fully understand the complex nature of the world in which they live. This assumes that the rational nature of agents allows them to continuously and accurately calculate the future implications of current policies and policy changes on inflation (De Grauwe, 2006). The rule that these forward-looking rational agents follow is specified as:

$$\pi_t = \pi_t^e + \varepsilon_t \quad (2.2)$$

where π_t is the inflation rate in the current period, π_t^e represents the expectation for the current inflation rate and ε_t represents a random error.

2.1.3 Learning

Until the early 1990s, theories about expectations formation were built on two extreme assumptions. On the one extreme were adaptive expectations, which assumed that individual agents are completely backward looking and have no understanding of the functioning of the economy, in contrast to the other extreme, called rational expectations, which assumed that individual agents are forward-looking and they fully understand the functioning of the economy. These agents are considered able to predict the future impact of current policies on the economy perfectly. In light of these two extremes, Sargent (1993) introduced the concept of "bounded rationality", whereby agents in the economy face limitations on knowledge about the functioning of the economy. They learn from past errors which indicators they should include in their rule and which to ignore and these agents then adjust their expectations rule over time. With regard to the knowledge that agents have about the economy, this seems to be a more realistic assumption, as even economists who postulate rational expectations, do not have perfect knowledge of the economic system and therefore need to estimate these relations using econometric techniques (Evans and Honkapohja, 2001).

3 Inflation expectations formation in South Africa

3.1 The labour market

Economic behaviour of agents may also provide some information about the process of forming inflation expectations. In South Africa, trade unions play a significant role in wage setting processes (see e.g. Azam and Rospabé, 2007). Therefore, the rates at which trade unions settle wage negotiations could provide some information about their inflation expectations.

Figure 1 Wage settlement rates, CPI and CPIX inflation rates

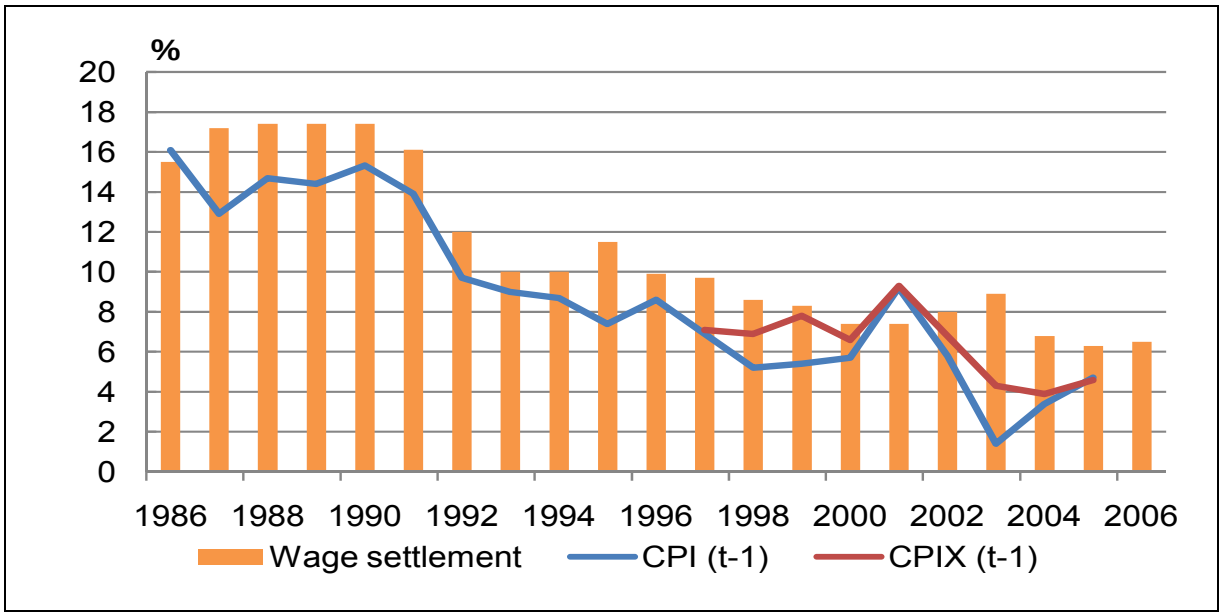


Figure 1 portrays average wage settlement rates[3] against inflation as measured by changes in the consumer price index (CPI) and the consumer price index, excluding mortgage interest costs (CPIX), lagged by one year to illustrate the correlation. It appears especially during the 1990s that wages were set considering the previous year's rate of inflation rather than current or future expected rates of inflation. This view is supported empirically by Aron et al. (2003).

3.2 Inflation expectations surveys

The availability of data on South African inflation expectations is quite limited and the best available proxies now are surveys that currently have very small sample sizes, as most of these surveys were only initiated during the late 1990s. There are two sources of survey data for South African inflation expectations namely the Reuters Inflation Expectations (RIE) Survey and the Bureau of Economic Research (BER) Inflation Expectations Survey.

The usefulness of survey data is at times considered and in particular, Thomas (1999) warned that survey data might have inherent problems that make inference

[3] Source: Andrew Levy Wage Settlement Surveys.

from tests performed on these surveys questionable. He based his statement on the consideration that individuals may have insufficient incentives to make optimal use of their resources when responding to the survey. Furthermore, some forecasters may even behave strategically by concealing their true forecasts. These warnings by Thomas indicate a potential source of statistical bias in the surveyed individual forecasts. When rational expectations are interpreted in the context of Muth (1961) where individuals' subjective expectations are exactly the true mathematical conditional expectations as implied by the model itself, these biases of survey data should be handled with care.

However, rather than focusing on the rationality of individual forecasts, Thomas tested for the rationality of the consensus forecasts, i.e. the mean forecasts across surveyed respondents, thereby diverging from the sense of rational expectations as defined by Muth towards hypothesising across an aggregated group's inflation expectations. Secondly, Keane and Runkle (1990) explain that aggregation may conceal systematic individual differences and may to some extent eradicate these potential sources of bias noted by Thomas.

Lane (2003) interpreted Muth's (1961) definition of rational expectations such that rational expectations should be generated by the same stochastic process that generates the economic variable to be forecasted. He noted that the rational expectations hypothesis did not argue that agents are always correct in their expectations of future variables. However, on average, rational expectations will be correct because the mean of the forecast error is zero and these expectations will have minimum variance. In this context, the rational expectations hypothesis does not apply to every individual, but only to the consensus or average expectation. More specifically, some individuals may irrationally over-predict and others may under-predict, but this does not imply that the expectations formation process in the economy is, on average, not rational.

Since the introduction of an inflation-targeting framework, agents are compelled to consider expected future rates of inflation as well as the inflation target rate. This may cause a change in the methods agents use to estimate future inflation outcomes.

To investigate the hypothesis of rationality, both the RIE and BER Survey data are separated into two periods, one to represent the disinflation environment[4] i.e. from January 2000 to the end of 2003, and the other to represent the stable-inflation environment where consumer inflation rates remained within the target band, i.e. from January 2004 to March 2007. Of interest is the longer-term expectations formation process and, in particular, the impact the target band had on respondents' longer-term views. Therefore, the six-quarter-ahead forecasts based on the quarterly data of the RIE Survey are used and the one and two-year-ahead forecast for average annual inflation data of the BER Survey. The data are analysed graphically by means of a histogram where each bar indicates the number of respondents recorded for each inflation expectation interval.

3.2.1 The RIE Survey data

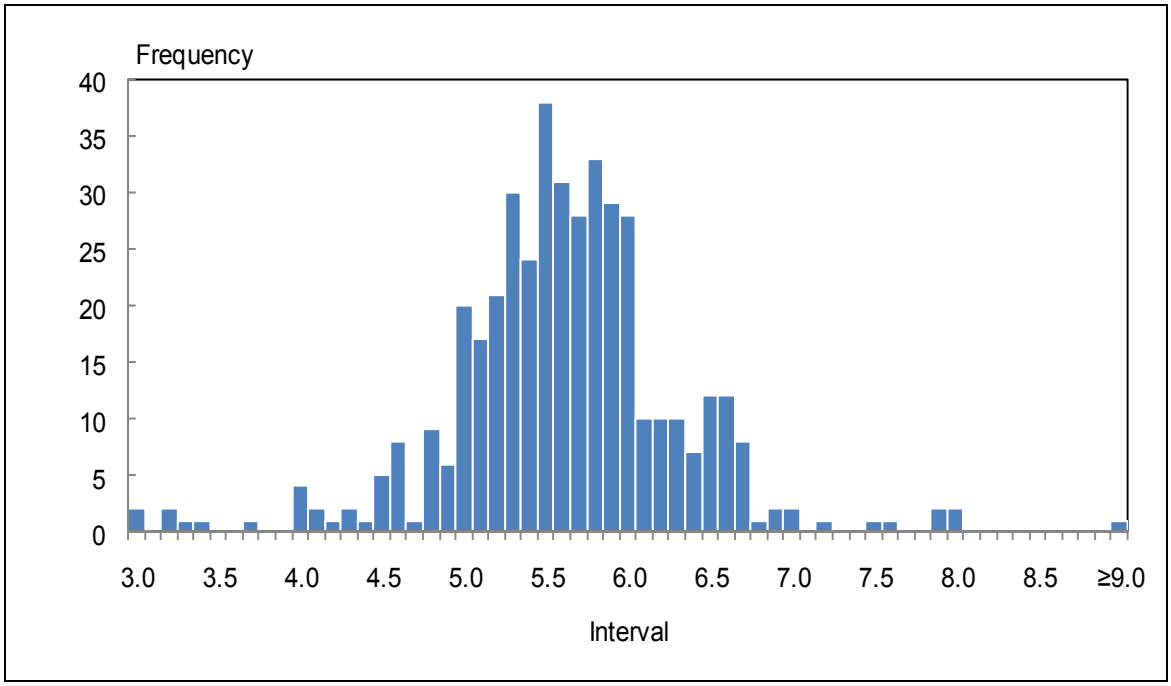
A benefit of the RIE Survey is that each individual forecast is identified by the institution that produced it, thereby adding an element of accountability as opposed to forecasts that were made anonymously. Furthermore, it is reasonable to assume that each institution represented in this survey has the ambition to forecast inflation as accurately as possible by utilising all available resources towards this end. Also, it is unlikely that the forecasts submitted by each institution over time, have been prepared by one individual using one particular forecasting methodology, but rather that these forecasts were more likely prepared by different individuals or groups within each institution, applying the forecasting methodology they believed will be the most appropriate to produce an accurate forecast of inflation. The net result and ultimately the benefit of this is that the dataset implicitly represents a process where agents follow an optimising process to form their expectation of future inflation as accurately as possible, and is not limited to one individual's opinion or one particular forecasting methodology.

Figures 2 and 3 compare the data from the RIE Survey, where the former portrays the data for the disinflation period and the latter the stable-inflation period where inflation was within the target band. It appears from Figure 2 that the longer-term

[4] The inflation-targeting framework was announced in February 2000 with a target band set for 2002.

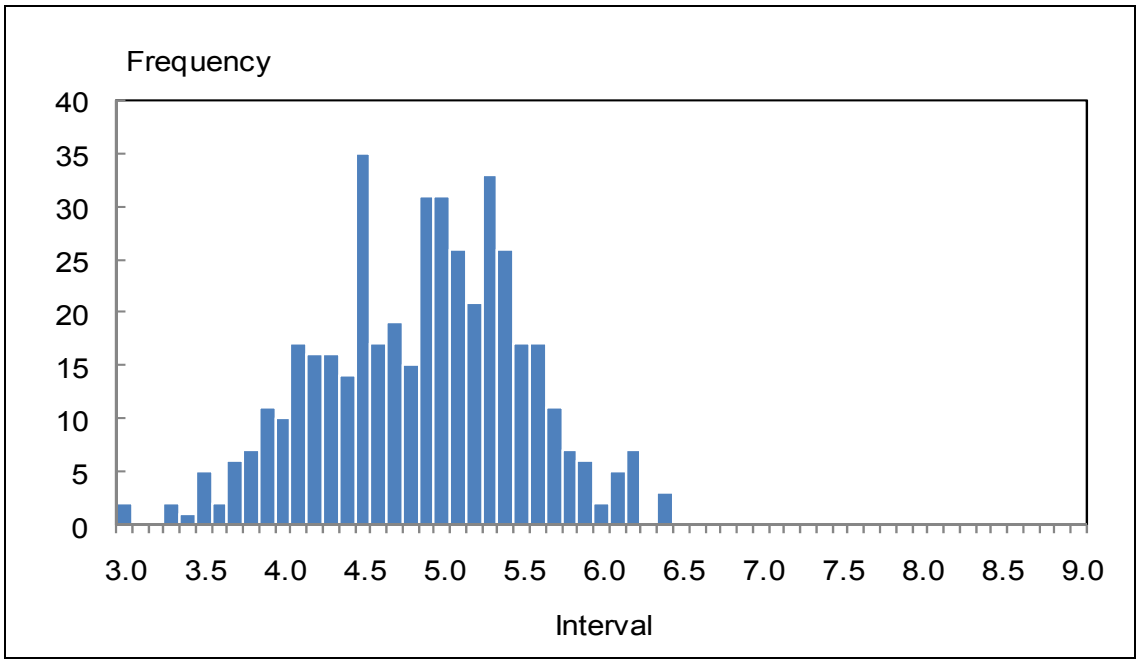
inflation expectations (i.e. 6 quarters ahead) are centred at 5,5 per cent, close to the upper target band of 6 per cent, with a few respondents expecting a breach of the upper target band.

Figure 2 RIE six-quarter-ahead survey data: Disinflation period



Over the stable-inflation period, the distribution of the longer-term inflation expectations has shifted lower, as depicted in Figure 3. The mean of the disinflation period is 5,6 per cent compared to the mean of the stable-inflation period of 4,9 per cent. The distribution has also changed from a skewed distribution in the disinflation period to a normal distribution in the stable-inflation period and the maximum interval fell from 9 per cent to 6,4 per cent. It is important to note that the interval at the midpoint of the target, i.e. 4,5 per cent, recorded the most observations, indicating that many respondents consider it a credible and plausible longer-term inflation outcome compared to the disinflation period where most respondents were centred around inflation expectations of 5,5 per cent. Based on the RIE Survey, it therefore appears that the inflation-targeting framework has succeeded in anchoring longer-term inflation expectations closer to the midpoint of the target range.

Figure 3 RIE six-quarter-ahead survey data: Stable-inflation period



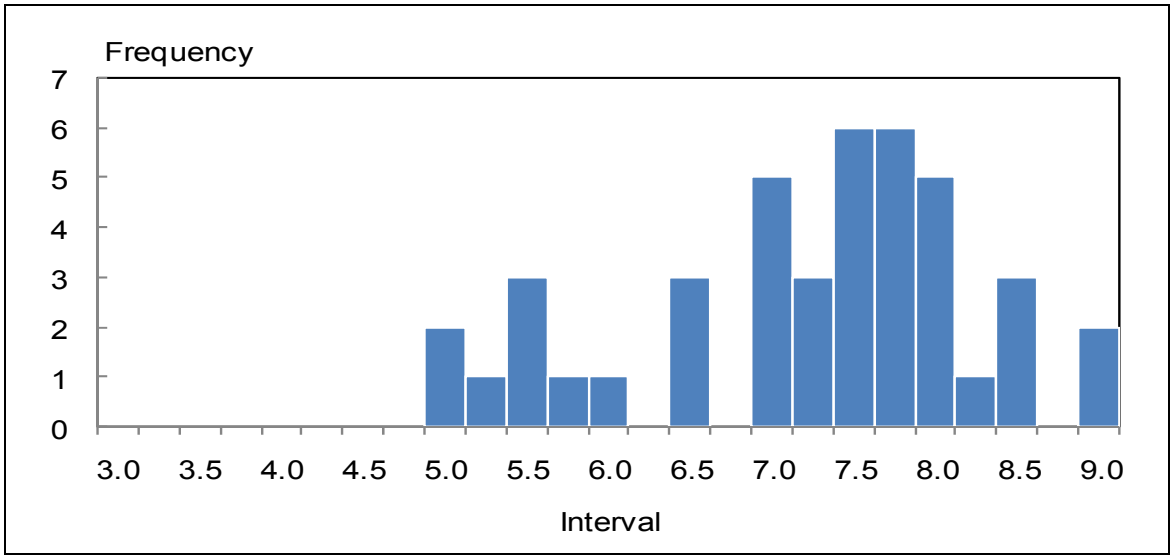
3.2.2 The BER Survey data

As noted earlier, the BER Survey data are published quarterly and records the inflation expectations for the current year and the next year by three different economic groupings in the economy[5]. To compare the longer-term inflation expectations during the disinflation and stable-inflation periods, the average for all three groups in the BER Survey is used as proxy for one and two-year-ahead inflation expectations.

The one-year-ahead BER inflation expectations results for the disinflation period as shown in Figure 4 indicate that most of the respondents (81 per cent) believed that inflation will be outside the target range, with the mode (the interval with the highest frequency) at the 7,5 to 8 per cent interval.

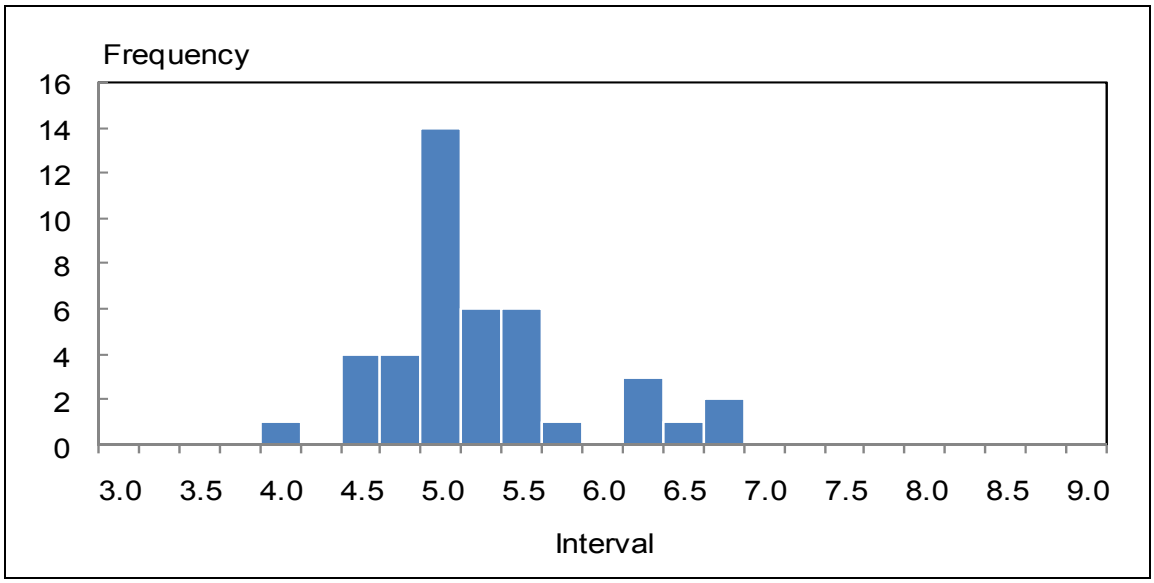
[5] The nature of the questions posed in the BER Survey entails that respondents are surveyed on their inflation expectations for a particular calendar year. Therefore, the BER Survey expectations reflect a time-varying horizon, contrary to the fixed-time horizon reflected in the RIE Survey. This implies that as the year progresses, additional actual inflation information is available which could impact on the expectation formation process of the BER respondents for the current calendar year's inflation expectation. However, for the sample under analysis, this did not impact on the results reported and the conclusions inferred.

Figure 4 BER one-year-ahead average inflation expectations: Disinflation period



From 2004, average inflation expectations recorded by the BER Survey were lower, as shown in Figure 5. Compared to the mean of 7,4 per cent during the disinflation period, the mean of the stable-inflation period slowed to 5,3 per cent. The credibility of the inflation-targeting framework also improved with time. In the stable-inflation period, 86 per cent of the respondents expected annual inflation one year ahead to be within the target range and the mode was at the 5-per-cent interval, which is closer to the midpoint of the target range.

Figure 5 BER one-year-ahead average inflation expectations: Stable-inflation period



The BER two-year-ahead inflation expectations, separated into the disinflation and stable-inflation periods, are compared in Figures 6 and 7, respectively. Similar to the one-year-ahead inflation expectations, most of the respondents (66,7 per cent) believed that the longer-term inflation outcome would be above the target band and the mode was at the 7,5 to 8 per cent interval.

Figure 6 BER two-year-ahead average inflation expectations: Disinflation period

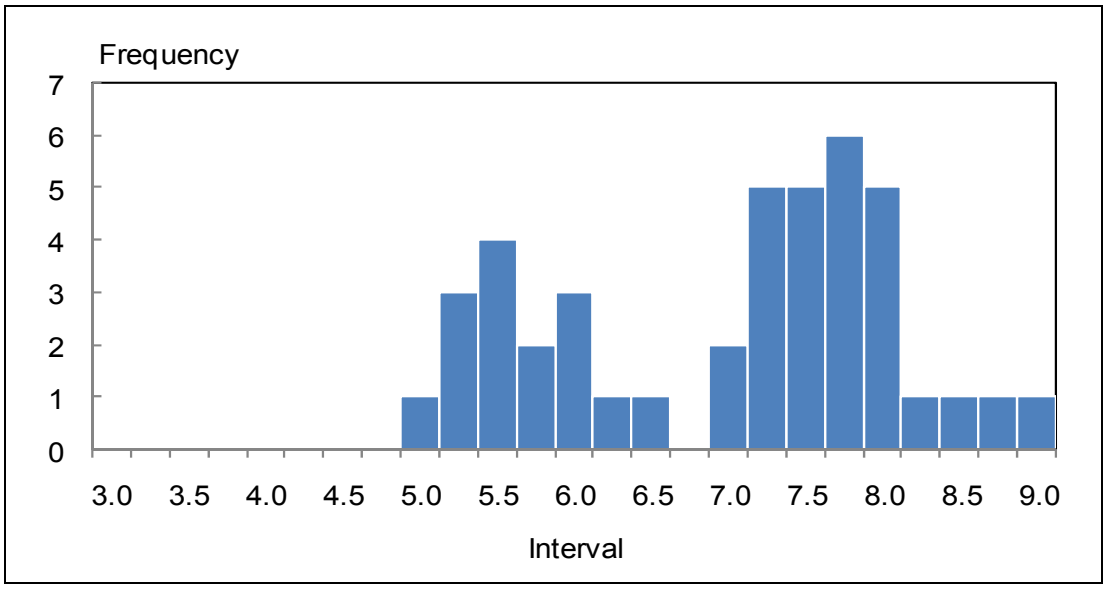
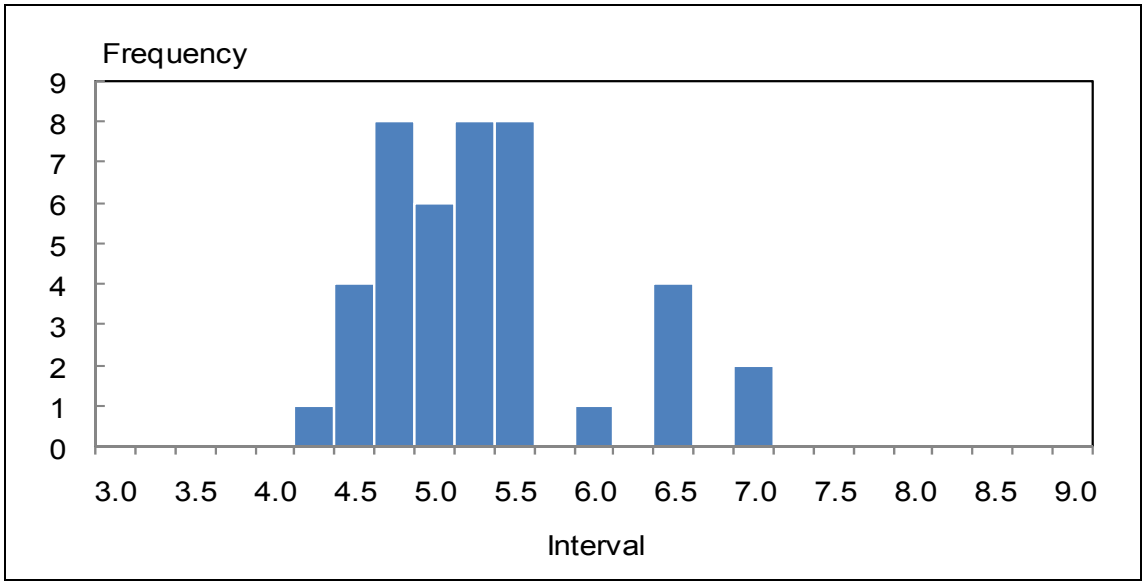


Figure 7 again provides evidence that after the disinflation period, longer-term inflation expectations were lower. The mean of the average two-year-ahead inflation expectations have slowed from 7,1 in the disinflation period to 5,4 in the stable-inflation period. Furthermore, 83,3 per cent of the respondents expected two-year-ahead inflation to fall within the target range.

Figure 7 BER two-year-ahead average inflation expectations: Stable-inflation period



In all three comparisons between the two periods, the standard deviations of the data had decreased between the disinflation and the stable-inflation period. This suggests more certainty among the surveyed agents about the longer-term outlook for inflation and increased credibility of the inflation-targeting framework.

4 Rational expectations

Associated with Muth (1961) is the notion of the rational expectations hypothesis that states agents use all cost-efficient information to make forecasts that are unbiased and efficient, i.e. expectations can be classified as weakly rational (see Koutsogeorgopoulou, 2000). Moreover, if forecasts obtained through surveys outperform forecasts by other models, such as ARMA models, then expectations may be classified as sufficiently rational (see Pearce, 1979, 1987). However, if the predictions by survey data outperform a combination of various forecast methods, expectations may be classified as strictly rational (see Granger and Newbold, 1973). Tests will be conducted in the following section to identify the most likely classification of South African inflation expectations using survey data.

4.1 Weak rationality

4.1.1 Unbiased inflation expectations

For expectations to be unbiased, the mean of expectations must be equal to the mean of the actual inflation outcome, i.e. the forecast error must be zero. In the literature, it has become standard practice to evaluate unbiasedness by estimating the following equation (see e.g. Forsells and Kenny, 2002):

$$\pi_t = \alpha + \beta E_{t-k}\pi_t^e + v_t \qquad (4.1)$$

where π_t is the inflation rate at time *t*, π^e_t is the expectation of inflation for time *t* formed at time *t-k*, α is a constant, *β* is a coefficient, *k* is the number of periods ago when the particular expectation was formed and v_t is a stochastic error.

According to the rational expectations hypothesis, expectations of inflation should be unbiased, which implies testing the joint hypothesis that α = 0 and *β* = 1. Furthermore, expectations of inflation should be efficient, which means that the forecast errors (v_t) should not be serially correlated. When this specification was estimated using data from the RIE and BER Surveys it was found that the errors were serially correlated (even after differencing the data), thereby providing an early indication of possible bias in the expectations formation process.

However, some authors question the validity of this form of rationality test. Granger and Newbold (1986) are of the opinion that a test of the joint hypothesis that α = 0 and *β* = 1 is a necessary condition for efficiency rather than a test for unbiasedness. Conversely, it was argued by Holden and Peel (1990) that a test of the joint hypothesis that α = *0 and β* = 1, is a sufficient, but not a necessary condition, for unbiasedness of expectations. They propose instead that the forecast error be regressed on a constant and that a t-test on the constant would provide correct conclusions concerning unbiasedness. This implies the regression:

$$\pi_t - E_{t-k}\pi_t^e = \alpha + v_t \qquad (4.2)$$

where π_t is the inflation rate at time *t*, π^e_t is the expectation of inflation at time *t* formed at time *t-k*, α is a constant, *k* is the number of periods ago when this expectation was formed and v_t is a stochastic error. The hypothesis that α = 0 is then tested by means of a t-test. The results of these tests are shown in Appendix A. Due to the existence of serial correlation, especially for forecasts made for one-year-ahead inflation (see Brown and Maital, 1981 and Mills and Peppers, 1999), the standard errors produced by using ordinary least squares estimation techniques will be both biased and inconsistent, although the method still yields consistent coefficients. Therefore, the covariance matrix is estimated by applying the procedure suggested by Newey and West (1987).

From Table A1 in Appendix A, the null hypothesis of unbiasedness for the RIE Survey is not rejected from the one-quarter-ahead to the six-quarter-ahead forecast periods, indicating that the RIE respondents (mostly financial analysts) form unbiased expectations of CPIX inflation, on average, for the period from the first quarter of 2000 to the first quarter of 2007. However, the expectation of the current-quarter inflation appears to be biased and the RIE respondents seem to overestimate CPIX inflation, on average.

The BER Survey provides insights into agents' longer-term expectations, as these surveys are conducted quarterly and reports the average annual CPIX inflation expectations for the current, one-year-ahead and two-year-ahead forecast horizons. These results are shown in Appendix A, Table A2. The overall expectation from the BER Survey, i.e. the total inclusive of the financial analysts, business representatives, and trade union officials, indicates the existence of bias in the expectation formation process, for the period from the third quarter 2000 to the fourth quarter 2006, where an overestimate, on average, of actual CPIX inflation was recorded for the current forecast horizon. Overall expectations for the one and two-year-ahead horizons were, on average, unbiased.

The BER Survey provides an opportunity to consider the extent of homogeneity in the inflation expectations formation bias of the three groups surveyed. These results

are shown in Table A3 in Appendix A. The results of the unbiasedness tests conducted on the expectations data of financial analysts, confirm the results from the RIE Survey, i.e. that financial analysts form unbiased expectations of CPIX inflation. Of the other groups that were tested, the trade union officials also form unbiased CPIX inflation expectations for the current-year period. The current-year and longer-term inflation expectations of the business representatives and the longer-term expectations of the trade union officials appear to be biased and both groups systematically overestimate CPIX inflation for the period under consideration.

4.1.2 Efficient inflation expectations

According to Mills and Pepper (1999) a sufficient condition for efficiency, with respect to the information set regarding the history of a particular variable, is that the forecast errors should be serially uncorrelated. The existence of correlation between the forecast errors implies that the respondents did not utilise all the information contained in past forecast errors to improve their expectations formation process, and agents are therefore not efficient in applying available resources.

This test involves estimating the following equation:

$$\pi_t - E_{t-k}\pi_t^e = \alpha + \sum_{j=1}^{n} \beta_j (\pi_{t-j} - E_{t-k}\pi_{t-j}^e) + \upsilon_t \qquad (4.4)$$

for each time horizon surveyed, where $(\pi_t - E_{t-k}\pi_t^e)$ represents the forecast error, t indicates time period t, α is a constant, β is a coefficient, j is the number of lags and v_t is a stochastic error. Model selection is based on the minimisation of the Akaike and Schwarz criteria. A Wald coefficient test is performed to test the hypothesis that all the coefficients and the constant are jointly equal to zero.

The results for the efficiency tests conducted on the data from the RIE and BER Surveys are reported in Appendix B. The results show that the null hypothesis of informational efficiency was rejected in all cases, except for the inflation expectations over the current-quarter horizon from the RIE Survey. This suggests that past forecast errors contain information that was not utilised by the respondents and therefore economic agents were inefficient in using the information at their disposal.

Although some of the groups in the BER Survey appear to form unbiased expectations of CPIX inflation, the overall lack of efficiency in using information from their available information sets, leads to the conclusion that none of the groups surveyed can be considered as weakly rational.

4.2 Sufficient rationality

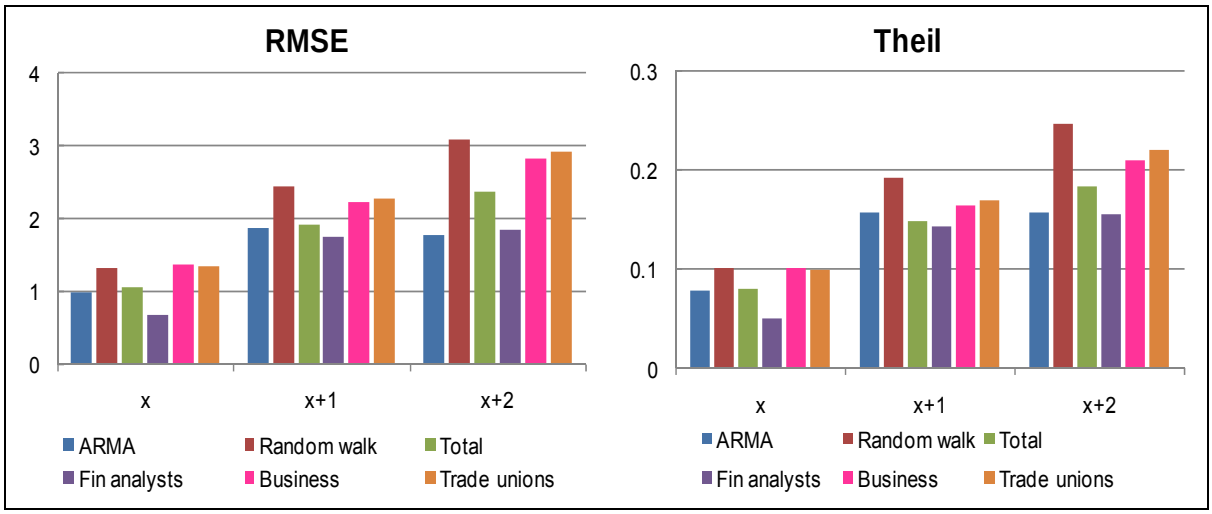
Pearce (1979, 1987) proposed that expectations data which have been classified as weakly rational (i.e. expectations that passed the tests for unbiasedness and efficiency), can subsequently be tested for sufficient rationality. Expectations survey data (i.e. forecasts) are classified as sufficiently rational if the survey data outperform forecasts of other models, such as a random walk and ARMA models.

Although the results reported in Section 4.1 show that expectations are not weakly rational and therefore do not qualify according to Pearce to be sufficient rational, the forecast performance will nevertheless be analysed, with this caveat in mind.

The forecast performance of the BER Survey is compared to that of a random walk and an ARMA model. Figure 8 indicates the root mean squared errors (RMSE) and Theil inequality coefficients for the BER Survey as well as that of an ARMA model and a random walk estimated using quarterly data[6]. For the current-year forecast horizon, the inflation expectations of the financial analysts in the BER Survey have an RMSE of 0,6580 and a Theil inequality coefficient of 0,0514, whereas the ARMA model has an RMSE of 0,9830 and a Theil inequality coefficient of 0,0777. The lower RMSE and Theil error statistics indicate that the expectations of financial analysts in the BER Survey outperform the forecasting capability of a simple ARMA model. Overall expectations for the current year's inflation do not outperform the ARMA model; however, they fare better than the random walk model according to both forecast error statistics. The expectations of business representatives and trade union officials outperform the random walk model according to the Theil inequality coefficient, but not according to the RMSE.

[6] See Appendix C for a technical discussion of these forecast error statistics.

Figure 8 BER Survey forecast error comparisons



A similar result is found when comparing the error statistics for the BER Survey for one-year-ahead inflation expectations in Figure 8. The forecast error statistics for the expectations of financial analysts are lower than those for the ARMA model. The ARMA model performs better than the overall BER inflation expectations as well as those of all three groups in the BER Survey. However, overall inflation expectations and those of each of the three groups perform better than a random walk model for both measures of forecast error.

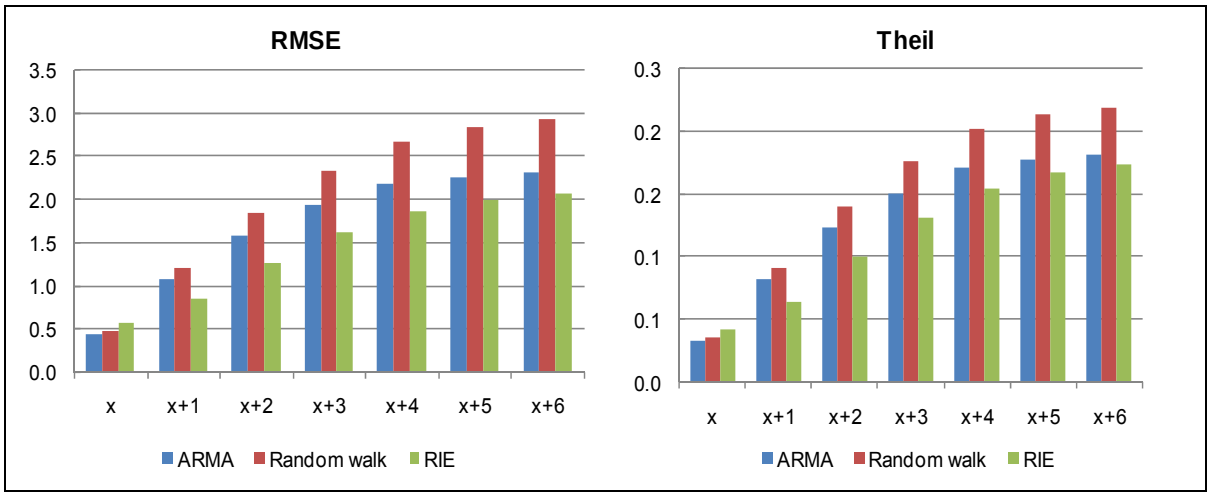
The two-year-ahead inflation expectations in Figure 8 indicate an ambiguous result[7]. According to the RMSE forecast error statistic, the ARMA model outperforms the BER Survey's overall inflation expectations, as well as those of all three different groups. However, according to the Theil inequality coefficient, the inflation expectations of financial analysts outperform the forecast of the ARMA model. The inflation expectations by all three groups outperform the random walk model for both forecast error statistics.

Figure 9 shows the RMSE and Theil inequality coefficient forecast error statistics for the forecasts from the RIE Survey as well as that of the ARMA model and a random walk estimated using monthly data.[8] For expectations of inflation in the current quarter, both the RMSE and Theil inequality coefficient indicate that the ARMA as

[7] See Appendix C for calculations.
[8] See Appendix C for calculations.

well as the random walk model outperform the consensus forecast in the RIE Survey. However, for expectations of inflation one period ahead up to six periods ahead, the RIE Survey outperforms the ARMA and random walk models, therefore passing the test for sufficient rationality over these forecast horizons.

Figure 9 RIE forecast error comparisons



The existence of weak rationality is a necessary condition for sufficient rationality (Razzak, 1997). Given that weak rationality was rejected in most instances, and the inconclusive results of the sufficient rationality tests, apart from financial analysts' expectations, the data from the RIE and BER Surveys show that economic agents do not form expectations rationally. However, the fact that inflation expectations survey data consistently outperform the forecasting capability of a random walk process provides evidence that the formation of inflation expectations in South Africa cannot be classified as naïve.

5 Adaptive expectations

Figlewski and Wachtel (1981) use data from the Livingstone Inflation Expectations Survey to estimate the following adaptive expectations rule:

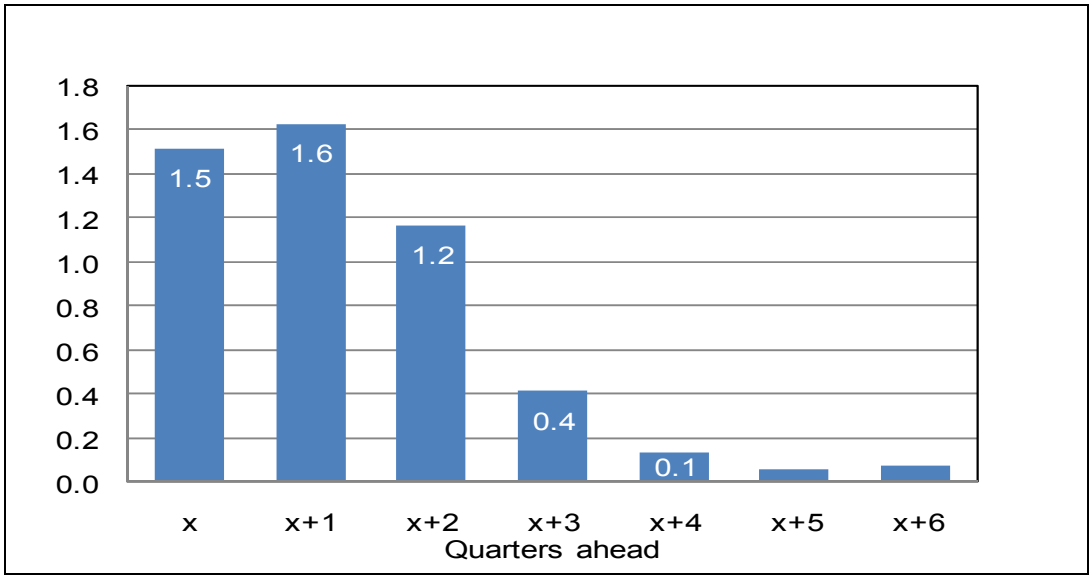
$$\pi_t^e - \pi_{t-1}^e = \alpha + \beta(\pi_{t-1} - \pi_{t-1}^e) \tag{5.1}$$

The model is specified with an intercept (α) to reduce the impact of any systematic measurement or specification errors on the estimated coefficient. The β represents the adaptive coefficient of agents with respect to the forecast error they had made in the previous period. The intuition behind this coefficient is that agents adjust their expectation about future inflation by some proportion of every percentage point forecast error they had made in estimating current inflation.

In this analysis, the above relationship is estimated over all forecast horizons for the RIE Survey as well as all three respondent groups of the BER Survey[9]. Figure 10 displays the magnitudes of the adaptive expectations coefficients for the RIE Survey over all seven of the forecast horizons. For every percentage point error made in their expectation for the previous quarter, analysts participating in the RIE Survey adjust their expectation for the current quarter, one-quarter-ahead and two-quarter-ahead inflation with 1,5, 1,6 and 1,2 percentage points, respectively. The adaptive coefficients for the three-quarter-ahead and four-quarter-ahead expectations decline to 0,4 and 0,1 percentage points, respectively, while the coefficients for the five-quarter-ahead and six-quarter-ahead expectations are not statistically significant from zero.

[9] The estimated coefficients with their accompanying t-statistics are reported in Table D1 and Table D2 in Appendix D.

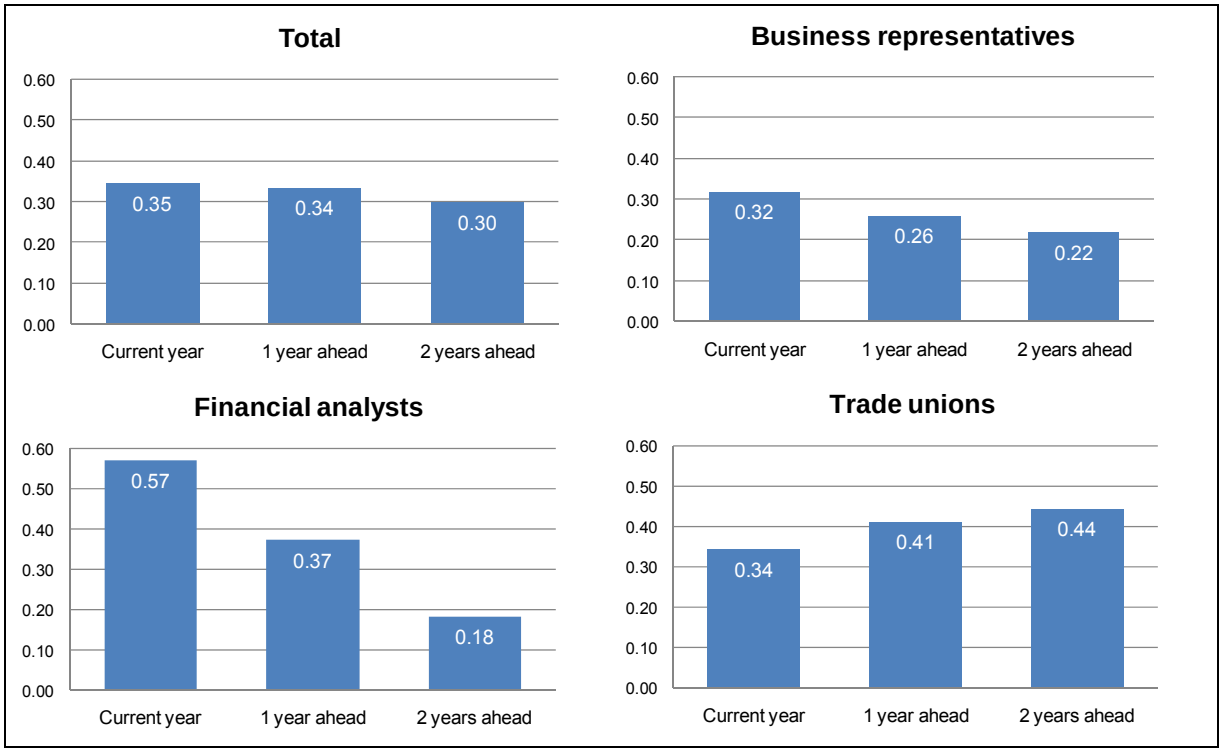
Figure 10 Adaptive expectations coefficients from RIE Survey



The fact that the shorter-term adaptive coefficients are larger than one, i.e. they adapt their forecast with a greater magnitude than the error made, indicates that the analysts participating in the RIE Survey tend to overreact to inflation surprises. Over the longer-term forecasting horizon, this effect is declining and much smaller in the sense that their longer-term views are not necessarily affected by current events, but rather based on other factors in their information set.

Figure 11 displays the magnitudes of the adaptive expectations coefficients for all three groups participating in the BER Survey over all three of the annual forecast horizons. The adaptive coefficients of the BER overall expectations imply that for every one-percentage-point error made on expectation for the previous year's inflation outcome, respondents adjust their inflation expectations for the current year, one year ahead and two years ahead by 0,35, 0,34 and 0,30 percentage points, respectively. For every one-percentage-point error that business representatives in the BER Survey made in the previous period, they adjust their expectations for the current year, one year ahead and two years ahead by 0,32, 0,26, and 0,22 percentage points, respectively. Financial analysts adjust their expectations for the current year's inflation by 0,57 percentage points for every percentage-point-error made, while they adjust their expectations for one year ahead and two years ahead by 0,37 and 0,18 percentage points, respectively.

Figure 11 Adaptive expectations coefficients from BER Survey



Trade union officials were the only group surveyed that appear to increase their adaptive coefficient over longer-term forecast horizons. They tend to extrapolate the impact of an inflation shock in the previous period, as they adjust their expectations for the current year by 0,34 percentage points, while increasing their adjustment to their expectations for one year ahead and two years ahead by 0,41 and 0,44 percentage points, respectively.

When comparing the adaptive coefficients of the RIE Survey to the financial analysts group in the BER Survey over the short run, i.e. the current year's expectation of the BER Survey compared to the RIE expectations for the current and the next three quarters, the adaptive coefficients from the RIE Survey are larger than the adaptive coefficient of the financial analysts surveyed by the BER. However, for the longer run expectation, i.e. the following year's expectation from the BER Survey compared to the RIE expectations for four, five and six quarters ahead, the adaptive coefficients from the RIE Survey are smaller than those of the financial analysts surveyed by the BER.

Possible reasons for the difference in the dynamics of these adaptive coefficients from the two surveys are firstly the difference in the survey frequency, where the RIE Survey respondents report their expectations regarding inflation on a monthly basis, and the BER respondents report their expectations on a quarterly basis, therefore the respective information sets used when reporting their expectations will differ. Secondly, the analysts in the RIE Survey report their expectation regarding quarterly inflation, whereas the BER Survey respondents report their expectation for annual inflation. Thirdly, individual forecasts of the RIE Survey are identified by the institution that produced them, thereby adding an element of accountability, contrary to the BER Survey.

6 Conclusion

The rational expectations hypothesis requires that inflation expectations should be unbiased and efficient predictors of inflation and produce forecasts that are at least superior to a random walk model. In this analysis tests were performed to evaluate these conditions in the RIE and BER Surveys.

The respondents of the RIE Survey appear to be unbiased over the full period under review, except for the current-period forecast horizon, where they were biased and produced overestimates of CPIX inflation, on average. This result is supported by analysis done on the data from the BER Survey, where the expectations of the financial analysts and short-term expectations by the trade unions officials appear to be unbiased. Expectations formed by the business representatives and longer-term expectations by the trade unions officials appear biased and indicate that they tend to overestimate CPIX inflation, on average.

The evidence from the information efficiency tests suggests that past forecast errors contain information that was not utilised fully by the respondents and, therefore, economic agents were inefficient with the use of information at their disposal, with the only exception being the current-period expectation from the RIE Survey. This leads to the conclusion that none of the surveyed groups show signs of a weak form of rationality over the period under investigation.

To determine the predictive ability of the agents surveyed in the RIE and the BER Surveys, the data are compared to a random walk and an ARMA model's forecasts. The RIE Survey outperforms the random walk model and the ARMA model across all forecast horizons except for the current-quarter expectation. Over the longer term (i.e. one year ahead and two years ahead), all the groups surveyed in the BER Survey outperform the random walk model, which indicates that expectations are not formed in a naïve manner. Only the forecast by financial analysts from the BER Survey outperformed the forecast by the ARMA model, indicating a better predictive ability.

The tests conducted to evaluate the extent of adaptive expectations formation from the BER Surveys for the one-year-ahead forecast horizon, indicate that trade union officials have the largest adaptive coefficient, whereas that of business representatives is the smallest. Furthermore, the results indicate that trade union officials adjust their inflation expectations at an increasing rate over the forecast horizon, contrary to the business representatives and financial analysts groups. Financial analysts do not include any significant contribution from past information and are hence probably not adaptive in forming their one-year-ahead inflation expectations. The fact that financial analysts do not exhibit adaptive expectation formation supports the finding that they are probably closer to rational expectation formulation than the other groups surveyed.

In general, the evidence from both the RIE and BER Surveys suggest that South African economic agents probably do not form their inflation expectations rationally. Therefore, it appears plausible that they employ some form of learning, considering the distributional changes from the disinflation period to the stable-inflation period, where the average inflation expectation slowed from around the upper range of the target in the disinflation period to closer to the middle of the target range in the stable-inflation period.

The lack of strong evidence for either full rationality or adaptive behaviour in the formation of inflation expectations leads to the conclusion that South African agents, in general, probably used a combination of both during the period under review.

Based on the evidence presented, it appears that economic agents employ some form of learning by combining some features of rationality with adaptive behaviour in order to minimise their forecast errors over time. However, this does not happen in a homogeneous manner as indicated by the differences in the adaptive coefficients of the various groups participating in the BER Survey.

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Appendix A: Unbiased test based on Holden and Peel (1990)[10]

Estimate equation: $\pi_t - E_{t-k}\pi_t^e = \alpha + v_t$

Perform t-test on α

Table A1 RIE Survey data

	Sample: First quarter 2000 to first quarter 2007	
Expectation	**T-test (prob)**	**Unbiased**
$E_t\pi^e_t$	-2,1227** (0,0428)	No
$E_{t-1}\pi^e_t$	-0,0643 (0,7510)	Yes
$E_{t-2}\pi^e_t$	0,3637 (0,7191)	Yes
$E_{t-3}\pi^e_t$	0,5969 (0,5560)	Yes
$E_{t-4}\pi^e_t$	0,6454 (0,5248)	Yes
$E_{t-5}\pi^e_t$	0,5602 (0,5808)	Yes
$E_{t-6}\pi^e_t$	0,5034 (0,6197)	Yes

** denote rejection at 5 per cent level of significance

[10] Due to the existence of serial correlation especially for forecasts made over one-year-ahead horizons (see Brown and Maital, 1981 and Mills and Peppers, 1999), the covariance matrix is estimated by applying the procedure suggested by Newey and West (1987) to yield consistent standard errors.

Table A2 BER Survey: Overall unbiased test results (third quarter 2000 to fourth quarter 2006)

	Overall	
Expectation	**T-test (prob)**	**Unbiased**
Current (x)	-2.0826 (0,0477)	No
x+1	-1.2317 (0,2295)	Yes
x+2	-0.7601 (0,4543)	Yes

Table A3 BER Survey: Business, financial analysts and trade union officials unbiased test results (third quarter 2000 to fourth quarter 2006)

	Business representatives		**Financial analysts**		**Trade unions officials**	
Expectation	**T-test (prob)**	**Unbiased**	**T-test (prob)**	**Unbiased**	**T-test (prob)**	**Unbiased**
Current (x)	-2,8138 (0,0094)	No	-0,7559 (0,4567)	Yes	-1,9159 (0,0669)	Yes
x+1	-2,7422 (0,0111)	No	0,9570 (0,3477)	Yes	-2,5491 (0,0173)	No
x+2	-2,4009 (0,0241)	No	1,4081 (0,1714)	Yes	-2,4301 (0,0226)	No

Appendix B: Tests for informational efficiency

Estimate following equation:

$$\pi_t - E_{t-k}\pi_t^e = \alpha + \sum_{j=1}^{n} \beta_j (\pi_{t-j} - E_{t-k}\pi_{t-j}^e) + \upsilon_t$$

Test null hypothesis for informational efficiency: H_0: $\alpha = \beta_j = 0$

Table B1 RIE Survey informational efficiency test results

Expectation	Lag (j)	Wald test	Null Hypothesis
Current (x)	1	p = 0,1028 (X^2)	Not reject
x+1	1	p = 0,0000 (X^2)	Reject
x+2	1	p = 0,0000 (X^2)	Reject
x+3	2	p = 0,0000 (X^2)	Reject
x+4	2	p = 0,0000 (X^2)	Reject
x+5	2	p = 0,0000 (X^2)	Reject
x+6	2	p = 0,0000 (X^2)	Reject

Table B2 BER Survey informational efficiency test results[11]

Respondent group	Expectation	Wald test	Null Hypothesis
Overall	Current (x)	p = 0,0000	Reject
	x+1	p = 0,0000	Reject
	x+2	p = 0,0000	Reject
Business representatives	Current (x)	p = 0,0000	Reject
	x+1	p = 0,0000	Reject
	x+2	p = 0,0000	Reject
Financial analysts	Current (x)	p = 0,0167	Reject
	x+1	p = 0,0000	Reject
	x+2	p = 0,0000	Reject
Trade unions officials	Current (x)	p = 0,0000	Reject
	x+1	p = 0,0005	Reject
	x+2	p = 0,0003	Reject

[11] Lag in equations is specified as 1 due to degrees of freedom constraints.

Appendix C: Description of forecast error test statistics

Forecast error test statistics

The sample for each forecast horizon is $j = T + 1, T + 2, ..., T + h$, where h is the number of forecasts made for the relevant horizon. The actual and forecasted value in each period are denoted by y_t and $\hat{y}_t$, respectively. The reported forecast error statistics are computed as follows:

Root mean squared error (RMSE): $$\sqrt{\sum_{t=T+1}^{T+h}(\hat{y}_t - y_t)^2 / h}$$

Theil inequality coefficient: $$\frac{\sqrt{\sum_{t=T+1}^{T+h}(\hat{y}_t - y_t)^2 / h}}{\sqrt{\sum_{t=T+1}^{T+h}(\hat{y}_t)^2 / h} + \sqrt{\sum_{t=T+1}^{T+h}(y_t)^2 / h}}$$

Table C1 BER Inflation Expectations Survey (quarterly survey)

	Current year		1-year-ahead		2-year-ahead	
	RMSE	**Theil**	**RMSE**	**Theil**	**RMSE**	**Theil**
ARMA model	0,9830	0,0777	1,8454	0,1566	1,7659	0,1574
Random walk	1,3161	0,1019	2,4291	0,1913	3,0756	0,2462
BER overall inflation expectations	1,0535	0,0801	1,9050	0,1476	2,3494	0,1837
BER financial analysts' expectations	0,6580	0,0514	1,7333	0,1430	1,8309	0,1554
BER business representatives' expectations	1,3507	0,1004	2,2087	0,1648	2,8097	0,2098
BER trade union officials' expectations	1,3225	0,1000	2,2504	0,1699	2,9034	0,2194

Table C2 Reuters Inflation Expectations Survey (monthly survey)

	ARMA model		Random walk		Reuters consensus	
	RMSE	Theil	RMSE	Theil	RMSE	Theil
Current	0,4330	0,0334	0,4733	0,0364	0,5617	0,0425
x+1	1,0622	0,0821	1,1901	0,0912	0,8349	0,0645
x+2	1,5813	0,1227	1,8273	0,1394	1,2581	0,1000
x+3	1,9277	0,1503	2,3191	0,1762	1,6092	0,1313
x+4	2,1796	0,1704	2,6627	0,2010	1,8602	0,1543
x+5	2,2495	0,1764	2,8307	0,2123	1,9919	0,1663
x+6	2,2961	0,1804	2,9189	0,2175	2,0655	0,1727

Appendix D: Estimated coefficients of adaptive expectations tests

Table D1 Adaptive expectations coefficients of RIE Survey

		β *
Reuters consensus (quarterly averages)	Current quarter (x)	1,5072 (4,6774)
	x+1	1,6208 (5,8204)
	x+2	1,1573 (4,5598)
	x+3	0,4076 (2,3225)
	x+4	0,1301 (1,9101)
	x+5	0,0484 (0,9989)
	x+6	0,0688 (1,7800)

* t-statistics in parenthesis (Newey-West standard errors)

Table D2 Adaptive expectations coefficients of BER Survey

		β *
Overall inflation expectations	Current year	0,3445 (5,7945)
	1 year ahead	0,3348 (4,8226)
	2 years ahead	0,2986 (3,3710)
Financial analysts	Current year	0,5689 (5,7589)
	1 year ahead	0,3709 (4,6627)
	2 years ahead	0,1825 (4,7811)
Trade union officials	Current year	0,3409 (3,4307)
	1 year ahead	0,4116 (3,4624)
	2 years ahead	0,4425 (2,7731)
Business representatives	Current year	0,3171 (5,2992)
	1 year ahead	0,2598 (5,1399)
	2 years ahead	0,2174 (4,3051)

* t-statistics in parenthesis (Newey-West standard errors)