Testing the Rationality of Consumer
Inflation Expectations in Japan

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This paper empirically examines the rationality of inflation expectations in Japan, with the estimated expected inflation rate obtained by the Kanoh (2006) procedure. The results of the bias existence test imply that the survey-based expectations are not consistent with weak-form rationality. Further, in the context of a cointegration analysis, we cannot confirm the rationality of inflation expectations through estimation based on the vector error correction model. Taken together, our findings indicate that inflation expectations formed by the consumer might be systematically biased or might not be weakly rational. In other words, consumers’ expectations, in general, are not always as accurate as the forecasts of economic theories and are incompatible with the concept of the rational expectations hypothesis.

1. Introduction

Inflation expectations play an essential part in the transmission of economic policy to the economy. Central banks monitor the inflation expected by the private sector, and firms should set prices as a mark-up over the weighted average of current and expected nominal marginal costs. Thus, the rationality of inflation expectation is of special importance, and a number of studies address the rationality of expected inflation. For instance, Evans and Wachtel (1992) empirically find that inflation expectations in the United States are biased and inefficient predictors. Thomas (1999) adopts a measure of inflation expectations given by the University of Michigan Surveys and finds rationality of expectations by the consumer, but Carroll (2003) rejects rationality with the same measure. Brissimis and Magginas (2008) estimate the New Keynesian Phillips curve with inflation forecasts given by the Federal Open Market Committee’s Greenbook and the Survey of Professional Forecasters, and conclude that expected inflation is the main determinant of current inflation. Gabriel (2010) reports the significant effect of changes in inflation expectations on prices and wages as a result of structural vector autoregression analysis for three European countries. Oral (2013) uses different procedures to quantify qualitative data, including the Carlson-Parkin method, the balance method, and the regression method, in order to estimate Turkish consumers’ inflation predictions, and rejects the pure backward- and forward-looking expectations
hypotheses by the regression method. On the other hand, some studies propose negative results for rational expectations based on the theory of bounded rationality. Branch (2004) and Pfajfar and Santoro (2006) are included in this category. These studies find that aggregate expectations consist of forecasting exercises by heterogeneous agents who use different methods and forecasting frameworks. From the viewpoint of non-stationary time series analysis, Grant and Thomas (1999) and Forsells and Kenny (2004) confirm rationality of consumers’ inflation expectations by using a cointegration framework.

Following the trend of recent studies described above, this paper empirically investigates the rationality of inflation expectations in Japan since 2004. Concretely, our research is composed of the following two steps. First, the expected inflation rate is estimated by the Kanoh (2006) method. Second, empirical tests and estimations are conducted to examine the rationality of expectations with the estimated expected inflation rate.

The remainder of this paper is organized as follows. Section 2 explains the Carlson-Parkin (1975) method and the Kanoh (2006) procedure. Section 3 is devoted to the empirical investigation of rationality of inflation expectations by tests based on forecast error and by estimation through the vector error correction model (VECM). Lastly, Section 4 presents the concluding remarks.

2. Estimation of Inflation Expectations

2-1 Inflation Expectations and Survey Data

Estimation of inflation expectations based on the data obtained from the survey enables us to consider the formation process of expectations by the public without any particular models. Concretely, there are two typical patterns of survey data on inflation expectations: qualitative and quantitative. In the case of qualitative surveys, respondents answer in a qualitative manner to a question such as, “Do you think that price level (or inflation) will have gone up (or down) one year from now?” The data on inflation forecasts given by surveys of this kind are usually presented in the form of a qualitative statistic indicating whether the majority of the polled respondents anticipate that price levels will rise, remain constant, or decline in the future. Therefore, this type of survey examines the general tendency of the expectation by the public. In contrast, respondents give an answer to the question in a quantitative manner in the case of a quantitative survey. It seems desirable to acquire a point forecast of the inflation expectation, but quantitative surveys may have some defects since this kind of direct measure is likely to be disturbed by measurement and sampling errors. From this point of view, it is preferable to utilize qualitative surveys along with a method of quantifying qualitative data.
2–2 The Carlson-Parkin Method

As described in the previous section, a procedure for quantifying qualitative survey data is required for studying inflation expectation. However, there are some problems with respect to the data obtained from a qualitative survey. For example, the respondents indicate only whether prices will “rise”, “fall” or “remain unchanged” for a certain period ahead in some surveys, and the data do not have a mean value since they are qualitative. To cope with these problems, several techniques, such as the Carlson-Parkin method, the balance method, and the regression method, have been developed.

The method of Carlson and Parkin (1975)\(^1\) is a typical probability approach for the inference of expected inflation. It assumes that the qualitative answer given by the respondent follows an individual probability distribution that is statistically independent of other respondents’ and normally distributed with finite mean and variance. The respondent is supposed to report the mean of the distribution. The Carlson-Parkin method postulates that respondents standing at time \(t\) form an inflation expectation for time \(t+1\) when they answer the survey. The joint probability distribution \(f(x_{t+1} | \Omega_t)\) can be derived by aggregation of individual subjective probability distributions, where \(\Omega_t\) is the information set at time \(t\) and \(x_{t+1}\) is the future change of prices in percentage of prices at time \(t\) for the period \(t\) to \(t+1\). This distribution is assumed to have finite first- and second-order moments, and can be expressed as \(E[x_{t+1} | \Omega_t] = \pi_{t+1}\), where \(\pi_{t+1}\) is the inflation expectation for the period \(t+1\). Furthermore, it is assumed that there exists an interval \((-\delta, \delta)\) around 0 (\(\delta > 0\)) such that the participants of the survey will report “no change” in prices if the expected price change lies within this interval. With this \(\delta\) (threshold), respondents are supposed to report the expectation of price change in the following manner:

- “prices up” if \(\pi_{t+1} > \delta\), \(\text{(1)}\)
- “prices down” if \(\pi_{t+1} < -\delta\), \(\text{(2)}\)
- “no change” if \(-\delta \leq \pi_{t+1} \leq \delta\), \(\text{(3)}\)

The report by the respondents can be interpreted as the result of an individual probability distribution over the possible future values of the variable in question and as a sampling from some aggregate distribution. Thus, the percentage of the responses of “prices up,” denoted \(UP\), and “prices down,” denoted \(DOWN\), can be transformed into the associated population values:

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\(^1\) The explanation given here is not identical to the original theory given by Carlson and Parkin (1975). The modified method in this section is of wide applications, and in line with the one introduced by some papers, for example, Henzel and Wollmershäuser (2006), Oral (2013), and Scheufele (2011).
\[ UP_t = 1 - \Phi \left( \frac{\hat{\delta}_t - \mu_t}{\sigma_t} \right), \]  
(4)

\[ DOWN_t = \Phi \left( -\frac{\hat{\delta}_t - \mu_t}{\sigma_t} \right), \]  
(5)

where \( \Phi \) is the cumulative distribution function of the standard normal distribution, and \( \mu_t \) and \( \sigma_t \) are respectively the mean and standard deviation of the aggregate distribution of inflation expectation. By considering these two equations, we have

\[ a_t = \Phi^{-1}(1 - UP_t) = \left( \frac{\hat{\delta}_t - \mu_t}{\sigma_t} \right), \]  
(6)

\[ b_t = \Phi^{-1}(DOWN_t) = \left( -\frac{\hat{\delta}_t - \mu_t}{\sigma_t} \right), \]  
(7)

where \( \Phi^{-1} \) is the inverse function of \( \Phi \). Then \( \mu_t \) and \( \sigma_t \) can be written as

\[ \mu_t = -\hat{\delta}_t \left( \frac{a_t + b_t}{a_t - b_t} \right), \]  
(8)

\[ \sigma_t = 2\hat{\delta}_t \left( \frac{1}{a_t - b_t} \right), \]  
(9)

if we have \( \hat{\delta}_t \). One simple way to obtain a plausible value of \( \hat{\delta}_t \) is to assume constant \( \hat{\delta} \) (i.e. \( \hat{\delta}_t = \hat{\delta} \) for some \( \hat{\delta} \)) and

\[ \sum_{t=1}^{T} \pi_t = \sum_{t=1}^{T} \mu_t, \]  
(10)

where \( \pi_t \) is the observed inflation rate. With these assumptions, we have

\[ \hat{\delta} = -\frac{\sum_{t=1}^{T} \pi_t}{\sum_{t=1}^{T} \left( \frac{a_t + b_t}{a_t - b_t} \right)}. \]  
(11)

Substituting this \( \hat{\delta} \) into (8) and (9) instead of \( \hat{\delta}_t \), we obtain \( \mu_t \) (expected inflation) and \( \sigma_t \) (standard deviation).

### 2-3 The Kanoh (2006) Procedure

Some problems have been pointed out with the basic Carlson-Parkin method. For instance, there is a chance that the thresholds are asymmetric between the expectations of “prices up” and “prices down”. By modifying the basic model, Kanoh (2006) proposes a procedure that can realize two kinds of threshold, namely, \( \hat{\delta}_1 \) for “prices up” and \( \hat{\delta}_2 \) for “prices down.” The
modifications by Kanoh (2006) are as follows.

The respondents are supposed to express an expectation of price change in the following manner:

- “prices up” if \( \pi_{t+1} > \delta_1 \), (12)
- “prices down” if \( \pi_{t+1} < \delta_2 \), (13)
- “no change” if \( \delta_2 \leq \pi_{t+1} \leq \delta_1 \). (14)

For the inferences of the mean and variance of the expectation series, the additional assumption is included:

\[ \sigma_t^2 = \sum_{t=1}^{T} (\pi_t - \bar{\pi})^2, \] (15)

where \( \bar{\pi} \) is the average rate of observed inflation. Equations (8) and (9) then become

\[ \mu_t = \left( \frac{a_t \delta_2 - b_t \delta_1}{a_t - b_t} \right), \] (16)

\[ \sigma_t = \left( \frac{\delta_1 - \delta_2}{a_t - b_t} \right), \] (17)

respectively, if we assume \( \delta_1 = \delta_1 \) and \( \delta_2 = \delta_2 \) for constants \( \delta_1 \) and \( \delta_2 \). After some manipulations, we have 3)

\[ \hat{\delta}_1 = \frac{1}{T} \left( \sum_{t=1}^{T} \pi_t + \sum_{t=1}^{T} \frac{a_t}{a_t - b_t} \sqrt{\frac{\sum_{t=1}^{T} (\pi_t - \bar{\pi})^2}{\sum_{t=1}^{T} \left( \frac{1}{a_t - b_t} \right)^2}} \right), \] (18)

\[ \hat{\delta}_2 = \frac{1}{T} \left( \sum_{t=1}^{T} \pi_t + \sum_{t=1}^{T} \frac{b_t}{a_t - b_t} \sqrt{\frac{\sum_{t=1}^{T} (\pi_t - \bar{\pi})^2}{\sum_{t=1}^{T} \left( \frac{1}{a_t - b_t} \right)^2}} \right). \] (19)

Substituting (18) and (19) into (16) and (17), we obtain \( \mu_t \) and \( \sigma_t \) respectively.

2-4 Application of Consumer Confidence Survey to the Estimation of Expected Inflation

The consumer confidence survey conducted by the Economic and Social Research Institute (Cabinet Office, Government of Japan) 4) is one of the applicable data sources for empirical

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2) Kanoh (2006) proposes multiple procedures for the inference of inflation expectations. The procedure applied in this paper is one of them.

3) Kanoh (2006) verbally explains his modification without any concrete derivation processes of \( \delta_1 \) and \( \delta_2 \). However, with some calculations with given assumptions and conditions, we are able to have equations (18) and (19).
study based on the Carlson-Parkin-type approach in Japan. Monthly data are available from April 2004 onward. Concretely, the qualitative data obtained from the section “price expectations a year ahead” in the consumer confidence survey can be utilized in our empirical study of inflation expectations. The survey is conducted monthly, and the participants are asked to assess the general situation and expectation about Japan’s economy.

In the item “price expectations a year ahead,” respondents give their expectations of future price level as “go down,” “stay the same,” “go up,” or “don’t know,” as indicated in Table 2-1, which is an example of the survey results. We use the data acquired from the consumer confidence survey\(^5\) to infer expected inflation.

### 3. Tests of Rationality of Inflation Expectations and Empirical Results

In this section, the weak-form rationality of inflation expectations is tested by using the estimated expected inflation rate. The Japanese monthly data of consumer price index,

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**Table 2-1** Example of the Survey Result of “Price Expectations a Year Ahead”

<table>
<thead>
<tr>
<th></th>
<th>Go down</th>
<th>Stay the same</th>
<th>Go up</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>greater than or equal to -5%</td>
<td>less than -5% to greater than or equal to -2%</td>
<td>less than -2%</td>
</tr>
<tr>
<td>2012 Jul</td>
<td>1.7</td>
<td>2.6</td>
<td>4.4</td>
</tr>
<tr>
<td>Aug</td>
<td>1.3</td>
<td>2.1</td>
<td>5.6</td>
</tr>
<tr>
<td>Sep</td>
<td>1.1</td>
<td>1.9</td>
<td>5.0</td>
</tr>
<tr>
<td>Oct</td>
<td>0.8</td>
<td>2.5</td>
<td>4.4</td>
</tr>
<tr>
<td>Nov</td>
<td>0.7</td>
<td>1.9</td>
<td>5.6</td>
</tr>
<tr>
<td>Dec</td>
<td>0.7</td>
<td>2.4</td>
<td>6.3</td>
</tr>
</tbody>
</table>


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\(^5\) Some noteworthy points about the consumer confidence survey are as follows. (a) The survey of “price expectations a year ahead” is conducted across three categories: “all households”, “all households except one-person households”, and “one-person households.” (b) From May 2004 to February 2007, the survey was conducted by telephone in months other than June, September, December, and March; the survey was conducted by direct-visit and self-completion questionnaires in June, September, December, and March. (c) Since April 2013, the survey has been conducted by mail. In addition, the number of sample households has been increased from 6720 to 8400. Therefore, survey data between March and April in 2013 are discontinuous.
change from the previous year (excluding fresh food, whole Japan, total) spanning the estimation period from April 2004 to March 2014. The data on “consumer price index” were retrieved from the “Portal Site” of Official Statistics of Japan administered by the Ministry of Internal Affairs and Communications, Statistics Bureau, Director-General for Policy Planning (Statistical Standards) & Statistical Research and Training Institute (in English) “http://www.e-stat.go.jp/SG1/estat/eStatTopPortalE.do”.

Inference of the expected inflation rate is implemented by the Kanoh (2006) procedure explained in Section 2. The qualitative data obtained from the consumer confidence survey for “all households” is used for inference. For simplicity, the “don’t know” answers in the results are combined with “stay the same” answers. The total of the ratios for each month sometimes exceeds 100% due to round-off errors. To cope with this problem, the ratios are adjusted as the proportional allotments based on the total sum of the ratios. In addition, the ratios in three items of “go down” and “go up” are respectively combined into the total of “go down” and the total of “go up” for our estimation. The estimated $\delta_1$ and $\delta_2$ by the Kanoh (2006) procedure are $\delta_1 = -0.34202126$ and $\delta_2 = -1.29677537$. Since the ideal signs are $\delta_1 > 0$ and $\delta_2 < 0$, the estimated $\delta_1$ is unfavorable. However, this result is applicable to our estimation since at least one of the two thresholds is in line with the assumption. Figure 3–1 illustrates the estimated expected inflation rates by the Kanoh (2006) procedure.

One of the issues with regard to the formation process of inflation expectation is the exploration of forecast bias. Suppose we can define the forecast error as $\pi_t - \pi_{t-h}^f$, where $\pi_t$ is the observed rate of inflation and $\pi_{t-h}^f$ represents the inflation expectation formed for a forecast horizon of $h$ periods (or the inflation expectation for period $t$ formed at period $t-h$). According to the rational expectations hypothesis, the forecast error should have a white noise process with zero mean. This condition requires the inflation expectations by the public to be unbiased and efficient. To implement the bias existence test for checking the “weak-form rationality” in our context, we first implement the estimation by the following equation:

$$\pi_t = \alpha + \beta \pi_{t-h}^f + \epsilon_t, \quad (20)$$

where $\epsilon_t$ is a random error. We set $h = 12$ because we consider expectations for one year in the future with monthly data. Second, we conduct the Wald Test with the null hypothesis $(\alpha, \beta) = (0, 1)$ by utilizing Newey and West (1987) heteroscedasticity- and autocorrelation-consistent (HAC) standard errors and the covariance matrix to deal with possible autocorrelation in the error term. The result of the test is reported in Table 3–1. The null
hypothesis is rejected at the 1% level of significance, suggesting the existence of a forecast bias. In other words, the result implies that recent survey-based inflation expectations in Japan are not consistent with weak-form rationality.

Another way of considering our interest with respect to inflation expectations is to examine whether the forecast errors are correlated positively with change in inflation. As described by Dotsey and DeVaro (1995) and DeLong (1997), it is often assumed that expectations tend to underestimate the inflation rate during periods of rising inflation and overestimate it during periods of falling inflation. Following this argument, we conduct the forecast-error-based expectation response test by the equation

$$\pi_t - \pi_{t-h} = \gamma_1 + \gamma_2 \Delta \pi_t + \epsilon_t,$$

with the determination made by whether the estimated value of $\gamma_2$ is positive and larger than one. The result of estimation is shown in Table 3-2. The significantly estimated coefficient of $\gamma_2$ is positive and larger than one, which implies a relatively active response for inflation expectations by the consumer to change in inflation.

Some techniques of non-stationary time series analysis can be applied to our investigation. Recall equation (20) to consider this problem. Ignoring the intercept for the sake of simplicity, we have the error term

$$\epsilon_t = \pi_t - \beta \pi_{t-h}.$$  

The error process is non-stationary, so the estimation of equation (20) may overstate the

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8) See, for example, Enders (2009) and Hamilton (1994) for details about non-stationary time series analysis.
influence of one variable on the other if the time paths of $p_t$ and $p_{t-h}$ are not linked. In addition, deviations of the paths of the variables from equilibrium\(^9\) will not disappear. Therefore, a spurious regression can occur in such a case. On the other hand, the error process is stationary if the time paths of $p_t$ and $p_{t-h}$ are linked or if the behaviors of these two variables follow a common time path. In this case, deviations of the time paths from equilibrium are only temporary. This desirable property is realized when the $p_t$ and $p_{t-h}$ are cointegrated with the cointegrating vector $[1, -\beta]$, and the cointegration makes a linear combination of these two variables stationary even if each time series is independently non-stationary. The time paths of the cointegrated variables depend on the degrees of deviation from equilibrium, and at least one of the variables should behave to restore equilibrium if the deviations are transitory. Consequently, if $\epsilon_t$ described above takes a positive or negative value at a certain time period, the equilibrium could be restored at the next period by the behavior of one of $p_t$ and $p_{t-h}$ or by the movement of both variables. By utilizing this error-correction property, we have a system of estimation with the error correction term $ECT_t = p_t - \beta p_{t-h}$ to evaluate the forecast rationality:

\(^9\) The term “equilibrium” is used in the statistical context.
\[ \Delta \pi_t = \gamma^\pi ECT_{t-1} + \epsilon_t^\pi, \]  
(23)

\[ \Delta \pi_t^e = \gamma^{\pi^e} ECT_{t-1} + \epsilon_t^{\pi^e}, \]  
(24)

and the augmented or general form with the lags of dependent variables having a white noise error becomes

\[ \Delta \pi_t = \gamma^\pi ECT_{t-1} + \sum_{i=1}^{l_1} a_{11} \Delta \pi_{t-i} + \sum_{i=1}^{l_2} a_{12} \Delta \pi_{t-i}^e + \epsilon_t^\pi, \]  
(25)

\[ \Delta \pi_t^e = \gamma^{\pi^e} ECT_{t-1} + \sum_{i=1}^{l_1} a_{21} \Delta \pi_{t-i} + \sum_{i=1}^{l_2} a_{22} \Delta \pi_{t-i}^e + \epsilon_t^{\pi^e}, \]  
(26)

where the lag of the error correction term is \( ECT_{t-1} = \pi_{t-1} - \beta \pi_{t-1, t-1} \). This system\(^{10}\) is a kind of the vector error correction model (VECM). If the two speed-of-adjustment coefficients are significantly estimated with the theoretically expected signs (\( \gamma^\pi < 0 \) and \( \gamma^{\pi^e} > 0 \)), we regard that forecasters respond to changes in inflation and, at the same time, that inflation responds to the behavior of the public, which forms the expectations. For example, \( \gamma^{\pi^e} \) should be significantly positive if the response to the forecast (expectation) error by the agents in previous period is appropriate. This implies rational expectation in the sense that the agents properly utilize the available information.

Before implementing the VECM estimation, we have to conduct the unit root test and the cointegration test to find the time series characteristics of the variables. First, augmented Dickey-Fuller (ADF) tests are conducted to examine the order of integration of each variable. According to the results of our tests (with and without drift and linear time trend), which are shown in Table 3-3, \( \pi \) and \( \pi^e \) have the same order of integration, I(1), at 5% level of significance.

Next, we proceed to the cointegration test. Table 3-4 displays the result of the Johansen test. Both the trace test and the maximum eigenvalue test (with no intercept or trend in the cointegrating equation or test VAR) find one cointegrating relation at the 5% level (for lag interval = 12) by applying the critical values of Osterwald-Lenum (1992) with the normalized cointegrating vectors\(^{11}\) [1, -1.814655].

The result of estimation by the VECM is presented in Table 3-5. The error correction term with one-period lag is \( ECT_{t-1} = \pi_{t-1} - 1.814655 \pi_{t-1, t-1} \). As described in the previous section, if two kinds of speed-of-adjustment coefficient are estimated as significant with the theoretically expected signs, we can assume that consumers’ inflation expectations follow a

\(^{10}\) Grant and Thomas (1999) express this system as a VAR augmented with an error-correction component.

\(^{11}\) Here, “normalized” means “normalized with respect to the dependent variable.”
process of weak-form rationality. According to the table, the expected conditions for the speed-of-adjustment coefficients are not realized since both $\gamma^r$ and $\gamma^{re}$ are positive and insignificant. In short, VECM estimation does not show the existence of weak-form rationality of inflation expectations.
4. Concluding Remarks

This paper empirically examines the weak-form rationality of inflation expectations in Japan since 2004 by utilizing the estimated expected inflation rate obtained by the Kanoh (2006) procedure. The results of the forecast-error-based expectation response test imply the relatively active response of inflation expectations by the consumer to changes in inflation. However, the results of the bias existence test do not support weak-form rationality of survey-based inflation expectations. Further, the estimation based on the vector error
correction model (VECM) in the context of a cointegration analysis does not find rationality of inflation expectations.

On the whole, our findings indicate that inflation expectations formed by the consumer might be systematically biased or might not follow the weak-form rationality. In other words, consumers’ expectations, in general, are not always as accurate as the forecasts of economic theories and are not compatible with the concept of the rational expectations hypothesis. Although our empirical study cannot directly detect the cause of bias and irrationality in the consumers’ expectation, it is probable that a staggered or sluggish formation of expectations is the underlying problem. Thus, further investigation of this unsolved problem is required.

References


