Disagreement and Biases in Inflation Expectations of Japanese Households

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Introduction (1) Biases of inflation expectations

(Overview of the dataset from 2004-2012)

✓ Compared with the current inflation rate (CPI, year-to-year change), positive bias exists through the period.
✓ The extent of the bias stays at the same level (around 1.5%).
✓ Even in the deflationary period, Japanese households tend to expect positive inflation rates.

<table>
<thead>
<tr>
<th>Year</th>
<th>Expected Rate</th>
<th>CPI (year-to-year)</th>
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</thead>
<tbody>
<tr>
<td>2012.12</td>
<td>1.59%</td>
<td>0.1%</td>
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<tr>
<td>2013.1</td>
<td>1.74%</td>
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</tbody>
</table>
Lacy measure: Simple measure of heterogeneity of survey responses (higher=greater heterogeneity)

\[ Lacy\ measure = \sum_{i=1}^{K-1} F_i (1 - F_i) \]

\(\checkmark\) Disagreement about inflation over the 12 months decreased when inflation rate rose, and increased when the rate reduced.
Even during the positive inflation period, disagreement about inflation over the 12 months tends to increase when the inflation rate reduced, and decrease when the rate increased.

Together with the observation about the bias, our starting point is to find an answer to the questions:

- Why are there biases?
- Why does the heterogeneity exist? What kind of attributes are behind the heterogeneity?
Literature on biases and heterogeneity of inflation expectations

1. Sticky information model
   ✓ Mankiw, Reis, and Wolfers (2003): Sticky information model is consistent with the US data (some consumers use outdated information to form their inflation expectation)
   ✓ Hori and Kawagoe (2011): Sticky information model can better explain the Japanese data, compared with the rational expectation model.

2. Other explanation? Models on the information processing
   ✓ Elliott, Komunjer and Timmermann (2008): Asymmetric loss can explain why the hypothesis of rationality is quite likely to be rejected. Consumers try to avoid the shock from unexpected “undesirable outcome” for them (i.e. high inflation).
   ✓ Captistran and Timmermann (2008): Asymmetric cost for consumers regarding over- and under-prediction of the inflation rate. Rational consumers have varied extent of such asymmetric property.

3. Further explanation?
   ✓ Malmendier and Nagel (2011): Learning-from-experience updating model (i.e. consumers form expectation based on the inflation rate they experienced, reflecting the most recent experience with greater weight)
Overview of data

- Two datasets from Consumer Confidence Survey (ESRI): (1) April 2006- June 2011 (panel data, monthly), and (2) June 1982-March 2004 (panel data, quarterly)
- Monthly panel contains around 297 thousand observations (30 thousand households), and quarterly panel contains around 370 thousand observations.
- Questions on the inflation expectations:
  (a) *Do you think the inflation rate increases in the upcoming 12 months, compared with the current rate?* (1982-1990FY)
  (b) *Do you think the inflation rate increases in the upcoming 6 months, compared with the current rate?* (1991-2003FY)
    * Qualitative responses are requested to the questions (a),(b).
  (c) *How do you expect the price levels of the goods you purchase frequently one year later?* (2004FY-)
    * Categorical responses are requested to the question (c). These can be used as quantitative data, by taking the median of each category.
- Questions on the household attributes (incl. age of the head, size of household, annual income, and occupation)
Forecast Errors: Inflation Data (All items)

Mean Forecast (2004M4～) and Inflation Data

Histogram of Mean Forecast Errors (2006.4～2011.6)
Forecast Errors: Inflation Data
(Frequently purchased items)

**Mean Forecast (2004M4~) and Inflation Data**

**Histogram of Mean Forecast Errors (2006.4~2011.6)**
Test of Unbiasedness

- A test of unbiasedness for each household
- Regressing the forecast errors \( e_{t+12,t,i} \) on a constant and applying a t-test

\[
e_{t+12,t,i} = C_{0,i} + \varepsilon_{t+12,t,i}
\]

where \( e_{t+12,t,i} = \pi_{t+12} - f_{t+12,t,i} \)

\( \pi_{t+12} \): CPI percentage change from twelve months ago at time \( t+12 \)

\( f_{t+12,t,i} \): 12 month ahead forecast for \( i' \)th forecaster (i.e. household)

- Significant bias for 12562 (61.8%) out of 20331 using the data □ (Inflation: All items)
- Significant bias for 10801 (53.1%) out of 20331 using the data □ (Inflation: Frequently purchased items)
The Theoretical Model for Bias

- We model asymmetric loss through the Linex loss function (Zeller, 1986)
  \[ L(e_{t+12,t} : \Phi) = \frac{1}{\Phi^2} [\exp(\Phi e_{t+12,t}) - \Phi e_{t+12,t} - 1] \]
  As \( \Phi \) (asymmetry parameter) \( \to 0 \), the loss approaches symmetric, mean squared error (MSE) loss.
- Under assumptions
  - Forecasters have the same degrees of loss asymmetry (\( \Phi = \Phi_i = \Phi_j = ... \))
  - Rational expectation
  - Forecaster’s information sets are identical and conditional on information available at time \( t \), inflation has a Normal distribution with conditional mean and variance (\( \mu_{t+12,t} \) and \( \sigma^2_{t+12,t} \))

Optimal forecast that minimizes expected loss function

\[ f^*_{t+12,t} = \mu_{t+12,t} + \frac{\Phi}{2} \sigma^2_{t+12,t} \]
Estimation

- We extend this model by allowing
  - forecasters have different degree of loss asymmetry, $\Phi_i$
  - a constant bias, $\pi_{b,i}$, which is not part of agent’s first order condition under rational expectation and is equal to zero if agents form rational expectation

\[ f_{t+12,t,i} = \mu_{t+12,t} + \Phi_i / 2 \sigma^2_{t+12,t} - \pi_{b,i} \]  \hspace{1cm} (1)

- We estimate a GARCH model (Engle, 1982) to obtain an estimate of the conditional variance of inflation ($\sigma^2_{t+12,t}$)
- Regressing the forecast errors ($e_{t+12,t,i}$) on a constant and the estimated conditional variance of inflation ($\sigma^2_{t+12,t}$)

\[ e_{t+12,t,i} = C_{0,i} + C_{1,i} \sigma^2_{t+12,t} + \varepsilon_{t+12,t,i} \]  \hspace{1cm} (2)

We apply a simple t-test to find out if the asymmetry parameters ($\Phi_i$) and a constant bias ($\pi_{b,i}$) are different from zero
Results

• The asymmetry parameters ($\Phi_i = 2C_{1,i}$) are significantly different from zero for
  3337 (16.4%) using the data $\diamondsuit$ (Inflation: All items)
  4902 (24.1%) using the data $\heartsuit$ (Inflation: Frequently purchased items)

• The constant bias components ($C_{0,i}$) are significantly different from zero for
  7327 (36.0%) using the data $\diamondsuit$ (Inflation: All items)
  5720 (28.1%) using the data $\heartsuit$ (Inflation: Frequently purchased items)
Cross-Section Dispersion

- We extend our model to analyze the cross-sectional dispersion in inflation forecast, 
  \[ s_{t+12,t} = \left[ \frac{1}{N} \sum_{i=1}^{N_t} (f_{t+12,t,i} - f_{a,t+12,t})^2 \right]^{1/2}, \]
  where the mean forecast \( f_{a,t+12,t} = \frac{1}{N_t} \sum_{i=1}^{N_t} f_{t+12,t,i} \)

- Under rational expectation, we get
  \[ s_{t+12,t} = \left[ \frac{1}{N} \sum_{i=1}^{N_t} (\Phi_i - \Phi_a)^2 \right]^{1/2} / 2 \sigma_{t+12,t} \tag{3} \]
  where the mean asymmetry parameter \( \Phi_a = \frac{1}{N} \sum_{i=1}^{N} \Phi_i \)

- To test the dependence of dispersion across forecasters on a constant and
  the conditional variance, we estimate
  \[ s_{t+12,t} = \gamma_0 + \gamma_1 \sigma_{t+12,t}^2 + \varepsilon_{t+12} \]
Test of heterogeneity

- Inflation expectations and HH characteristics
- Explained = Inflation expectations (mid-value)
- Estimation period=2006.4-2011.6
Test of heterogeneity

- Inflation expectations and HH characteristics
- Explained = Inflation expectation (category)
- Estimation period=1982.6-2004.3

<table>
<thead>
<tr>
<th>Category</th>
<th>HH characteristic 1</th>
<th>HH characteristic 2</th>
<th>HH characteristic 3</th>
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<tbody>
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<td>Category 1</td>
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<td>Category 15</td>
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Test of heterogeneity □

Estimation results:

✓ With the control of other demographic factors as well as CPI, the effect of the age looks inverted U-shaped.
✓ This shape is common, with the estimation of the separate samples of the surveys in the 1980s, 1990s, and 2000s.
✓ This shape remains stable as well, even with the control of the differences in consumption baskets. (Differences in expectations are much greater than those of the inflation.)
✓ The inverted U-shape is quite similar, among the samples of the beginning of the survey (i.e. first to third months) and those around the end of the survey (i.e. 13th to 15th months).
→ Even after one-year time, the disagreement between ages does not converge.
## Test of heterogeneity

<table>
<thead>
<tr>
<th>Survey</th>
<th>Period</th>
<th>CPI (level, year-to-year change)</th>
<th>Change in inflation expectation during the corresponding period</th>
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</thead>
<tbody>
<tr>
<td>Monthly</td>
<td>End 2007 – Mid 2008</td>
<td>Positive, increasing</td>
<td>Compared with the middle-aged,&lt;br&gt; • The young do not tend to raise their expectation.&lt;br&gt; • The elderly (over 70) tend to increase their expectation.</td>
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<tr>
<td></td>
<td>Latter half of 2008 – Fall 2009</td>
<td>Positive → Negative Decreasing</td>
<td>Compared with the middle-aged,&lt;br&gt; • The young tend to decrease their expectation.</td>
</tr>
<tr>
<td>Quarterly</td>
<td>End 1988 – First half of 1991</td>
<td>Positive, increasing</td>
<td>Compared with the middle-aged,&lt;br&gt; • The young do not tend to raise their expectation.</td>
</tr>
<tr>
<td></td>
<td>Mid 1998 – End 1999</td>
<td>Entering into the deflationary period Decreasing</td>
<td>No significant differences.</td>
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</table>
Heterogeneity in Asymmetry Parameters?

- Mean of the asymmetry parameters ($\Phi_i$) by age
The Theoretical Model for Learning from Experience

• Letting $f_{t+12,t,s}$ denotes mean inflation expectation made by cohort $s$ at time $t$ of the annual inflation rate over the next 12 months from survey data, we jointly estimate $\vartheta$ and $\theta$ the following equation with non-linear least squares

$$f_{t+12,t,s} = \theta \tau_{t+12,t,s}(\vartheta) + \delta' D_t + \varepsilon_{t,s}$$

This subjective expectation is a linear combination of the learning-from-experience component $\tau_{t+12,t,s}(\vartheta)$ and an unobserved common component, time dummies $D_t$.
The Theoretical Model for Learning from Experience

- The learning-from-experience $\tau_{t+12,t,s}(\theta)$ component is defined:
  
  $$\tau_{t+12,t,s}(\theta) = b'_t x_t$$

  where $b_t = (\mu_t, \Phi_t)'$ and $x_t = (1, \pi_t)'$

  assuming estimate of $b_t = (\mu, \Phi)'$ recursively from past data following:

  $$b_t = b_{t-1} + \gamma_t R_{t-1}^{-1} x_{t-12} (\pi_t - b'_{t-1} x_{t-12})$$

  $$R_t = R_{t-1} + \gamma_t (x_{t-12} x'_{t-12} - R_{t-1})$$

  The gain parameter $\gamma_t$ determines the degree of updating:

  $$\gamma_t (s) = \theta/(t-s) \quad \text{if } t-s \geq \theta$$

  $$\gamma_t (s) = 1 \quad \text{if } t-s < \theta$$
Inflation Expectation (Learning) young(20-24) vs old(75-90)
Tentative conclusions

✓ From the data between 2006-2011, we confirmed the existence of statistically significant upward bias.

✓ The “Model of asymmetric cost of forecast error” seems to be consistent with our data, while we have not confirmed that this model outperforms other models in explaining the heterogeneity or biases.

✓ Expectation differences among age groups remain persistent among the surveys in the varied decades, or among the beginning and the end of the sequence of the surveys.

✓ The above model can partly explain the heterogeneity among generations, but the extent is limited (we need another explanation!).

✓ Following the idea of the model, we would infer that the young people are the most optimistic, the aged moderately optimistic, and the middle-aged the most pessimistic regarding the possible negative impact of the growing inflation rate on their daily life.

✓ On the other hand, the model of “Learning-from-experience updating model” does not necessarily fit the inverted U-shape.
Summary & tentative message

(Possible source of persistent heterogeneity)

<table>
<thead>
<tr>
<th>Different information set</th>
<th>Different inflation experience</th>
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<tbody>
<tr>
<td>Different actual personal inflation rate</td>
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<table>
<thead>
<tr>
<th>Different information processing rule</th>
<th>Varied frequency &amp; timing of updating</th>
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<tbody>
<tr>
<td>Heterogeneity in loss functions</td>
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- Any one of the above factors/models cannot explain well the heterogeneity among demographic groups.
- Recent research has shown that some macro models may not have a stable equilibrium when there is heterogeneity of inflation expectations (e.g. Giannitsarou (2003)).
- We will need to examine carefully whether the expectations will begin to converge after the BOJ set the “price stability target” at 2 percent in January.