What Drove Japan's Deflation: Decomposition Analysis into Regular, Sales, Frequency, and Magnitude Components

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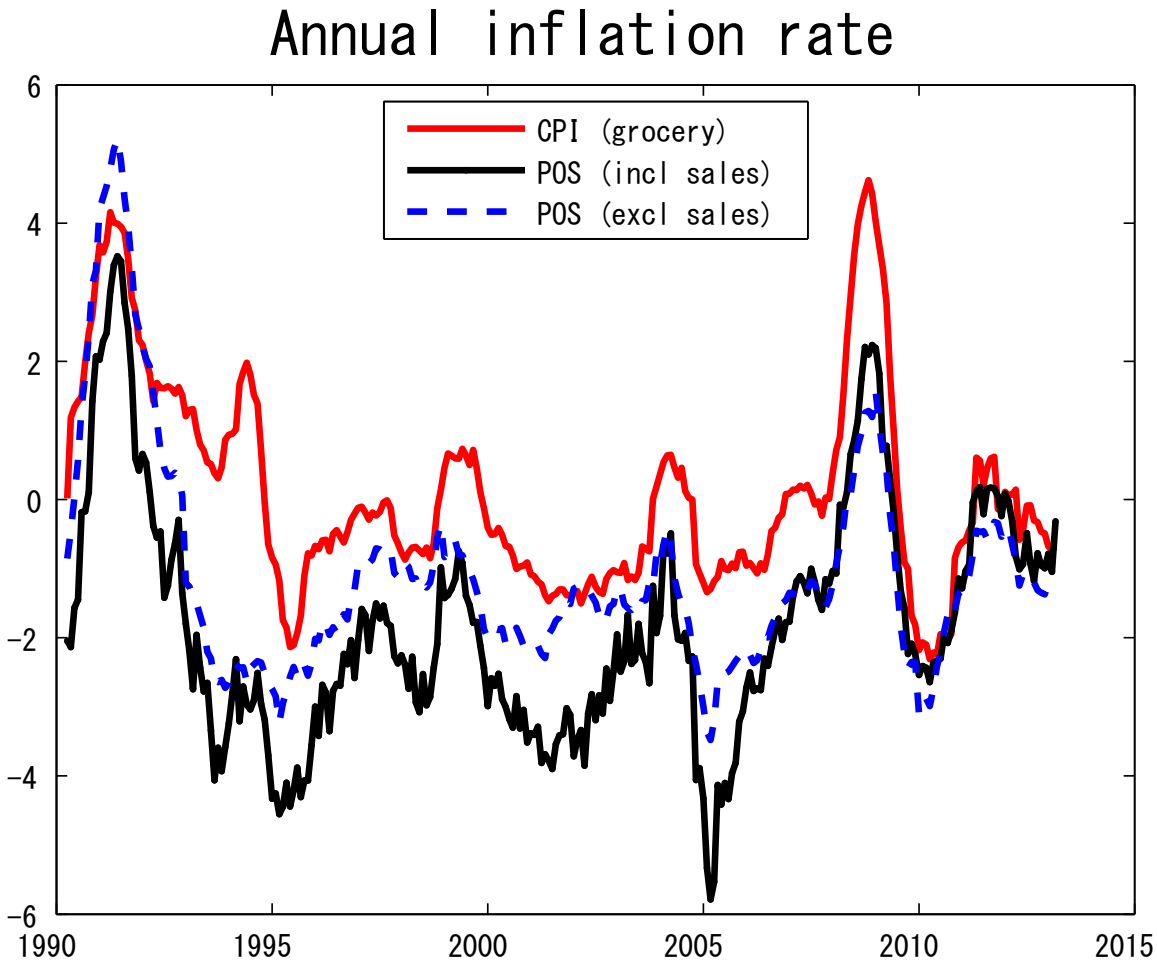
Views expressed in this paper are those of the authors and do not necessarily reflect the official views of the Bank of Japan. All errors are our own.

Motivation

Prolonged deflation during Japan's lost decades



Motivation

- We aim to study what drove Japan's deflation.
- To this end, we employ daily scanner or Point of Sales (POS) data
  - from 1988 to 2013
  - covering over 6 billion records
  - gathered by Nikkei Digital Media from various retail shops throughout Japan.
- We decompose inflation developments into
  - (i) regular and temporary sales
  - (ii) the frequency and magnitude of price changes.

Summary Results

1. Extensive margin, in particular, the frequency of downward regular price changes matters for Japan's inflation fluctuations under deflation.
2. The importance of common shocks is large for regular-price components and the frequency of temporary sales,
   while idiosyncratic shocks matter for inflation fluctuations, in particular, for the change in magnitude of temporary sales.
3. The frequency of regular price changes and the frequency of temporary sales are both significantly correlated with macro variables such as hours worked and the lagging index of business cycles.

Decomposing Inflation Rate

Formula (Extension of Klenow and Kryvtsov, 2008)

The POS inflation rate of 3-digit code item i, $\pi_{i,t} = p_{i,t} - p_{i,t-1}$ is expressed as

$$\begin{aligned}
\pi_{i,t} = & \frac{\sum_{j\in i}\omega_{j,t} I\{\Delta p^r_{j,t} > 2\}}{\sum_{j\in i}\omega_{j,t}} \cdot \frac{\sum_{j\in i}\omega_{j,t}\Delta p^r_{j,t} I\{\Delta p^r_{j,t} > 2\}}{\sum_{j\in i}\omega_{j,t} I\{\Delta p^r_{j,t} > 2\}} \\
& + \frac{\sum_{j\in i}\omega_{j,t} I\{\Delta p^r_{j,t} < -2\}}{\sum_{j\in i}\omega_{j,t}} \cdot \frac{\sum_{j\in i}\omega_{j,t}\Delta p^r_{j,t} I\{\Delta p^r_{j,t} < -2\}}{\sum_{j\in i}\omega_{j,t} I\{\Delta p^r_{j,t} < -2\}} \\
& + \frac{\sum_{j\in i}\omega_{j,t} I\{|p_{j,t} - p^r_{j,t}| > 2\}}{\sum_{j\in i}\omega_{j,t}} \cdot \frac{\sum_{j\in i}\omega_{j,t}\left(p_{j,t} - p^r_{j,t}\right) I\{|p_{j,t} - p^r_{j,t}| > 2\}}{\sum_{j\in i}\omega_{j,t} I\{|p_{j,t} - p^r_{j,t}| > 2\}} \\
& - \frac{\sum_{j\in i}\omega_{j,t} I\{|p_{j,t-1} - p^r_{j,t-1}| > 2\}}{\sum_{j\in i}\omega_{j,t}} \cdot \frac{\sum_{j\in i}\omega_{j,t}\left(p_{j,t-1} - p^r_{j,t-1}\right) I\{|p_{j,t-1} - p^r_{j,t-1}| > 2\}}{\sum_{j\in i}\omega_{j,t} I\{|p_{j,t-1} - p^r_{j,t-1}| > 2\}} \\
& + \varepsilon_{i,t}. \qquad (1)
\end{aligned}$$

Formula

It is denoted by

$$\pi_{i,t} \equiv fr_{i,t}^{r+} \cdot mg_{i,t}^{r+} + fr_{i,t}^{r-} \cdot mg_{i,t}^{r-} + fr_{i,t}^{s} \cdot mg_{i,t}^{s} - \tilde{fr}_{i,t-1}^{s} \cdot \tilde{mg}_{i,t-1}^{s} + \varepsilon_{i,t}. \quad (2)$$

It is approximated as

$$\begin{aligned}\pi_{i,t} \simeq & \left(fr_{i,t}^{r+} - \overline{fr_i^{r+}}\right) \cdot \overline{mg_i^{r+}} + \left(fr_{i,t}^{r-} - \overline{fr_i^{r-}}\right) \cdot \overline{mg_i^{r-}} \\ & + \left(mg_{i,t}^{r+} - \overline{mg_i^{r+}}\right) \cdot \overline{fr_i^{r+}} + \left(mg_{i,t}^{r-} - \overline{mg_i^{r-}}\right) \cdot \overline{fr_i^{r-}} \\ & + \left(fr_{i,t}^{s} - \tilde{fr}_{i,t-1}^{s}\right) \cdot \overline{mg_i^{s}} + \cdot \left(mg_{i,t}^{s} - \tilde{mg}_{i,t-1}^{s}\right) \cdot \overline{fr_i^{s}} + \varepsilon_{i,t}. \quad (3)\end{aligned}$$

Interpreation

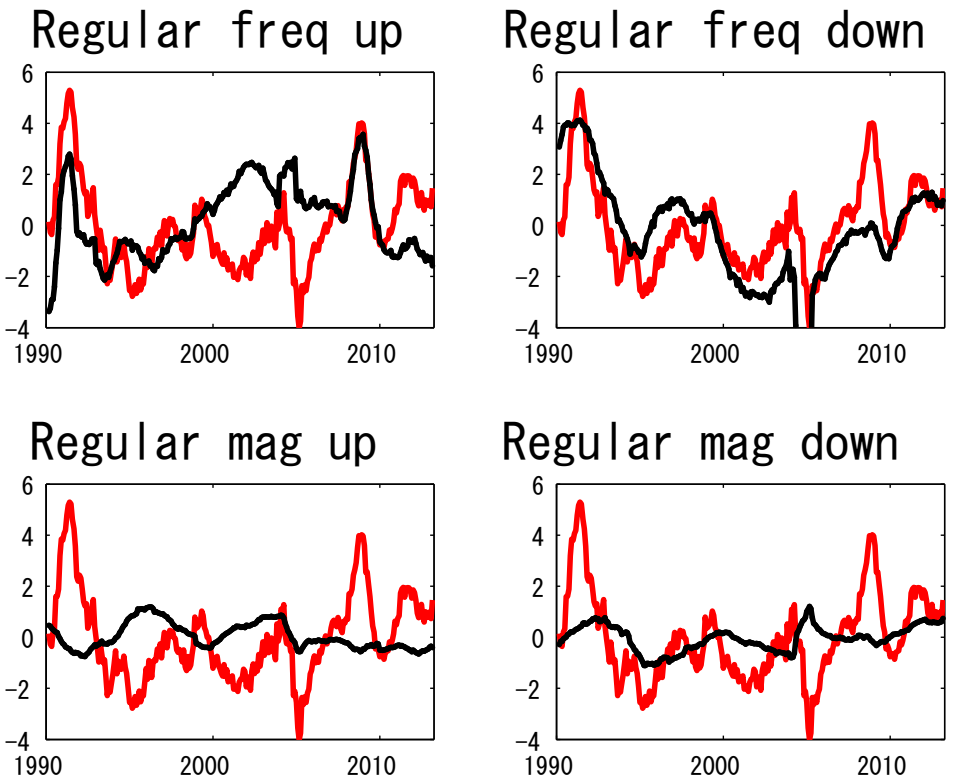
The inflation rate can be decomposed into 7 terms:

1. A deviation of the frequency of upward regular price change from its mean
2. A deviation of the frequency of downwardregular price change from its mean
3. A deviation of the magnitude of upwardregular price change from its mean
4. A deviation of the magnitude of downwardrregular price change from its mean
5. A change in the frequency of temporary sales
6. A change in the magnitude of temporary sales
7. Residuals

We then aggregate this across 3-digit code items to derive the aggregate inflation rate and the aggregated contribution of each components to the aggregate inflation rate.

Decomposition 1

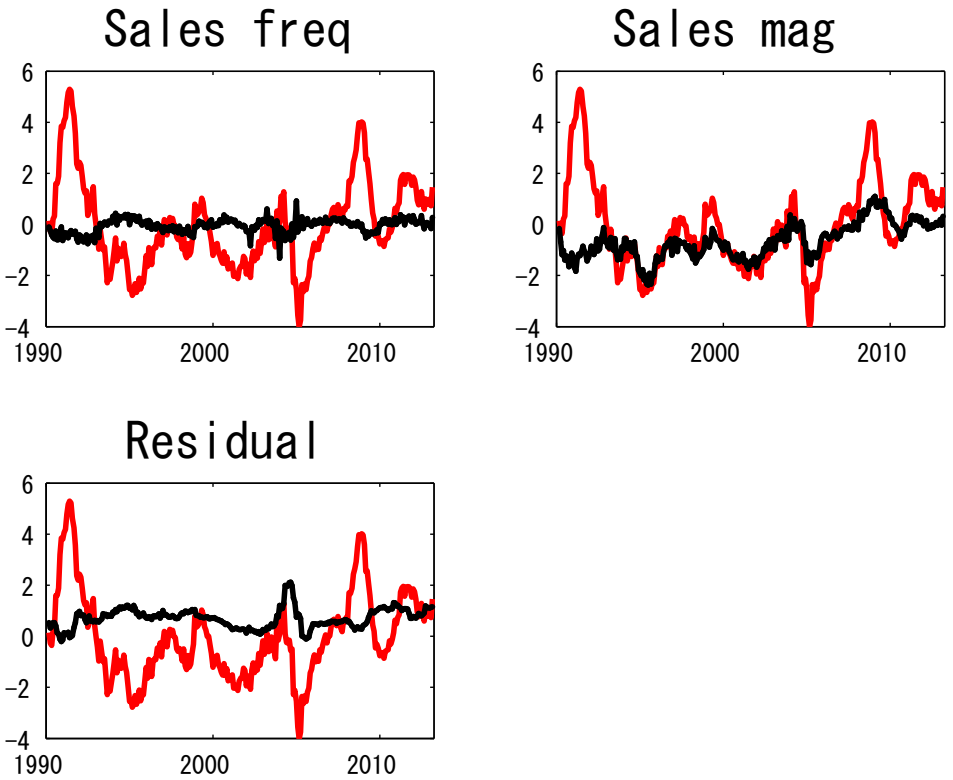
- Regular price frequency tracks well the path of the aggregate inflation.



A black solid line: the contribution of each component to the aggregated inflation rate depicted in a red solid line. All series in a 12-month backward moving sum.

Decomposition 2

- Sales magnitude tracks well the path of the aggregate inflation.



A black solid line: the contribution of each component to the aggregated inflation rate depicted in a red solid line. All series in a 12-month backward moving sum.

Variance Decomposition of POS Inflation Rate

- The frequency of downward regular price changes and the magnitude of temporary sales matter for the fluctuation of the inflation rate.
- When the aggregate inflation rate is higher (lower) than 0.5% (-0.5%), the frequency of upward (downward) regular price changes become increasingly important.

	Total (POS inflation rate)	Regular frequency up	Regular frequency down	Regular magnitude up	Regular magnituide down	Sale frequency	Sale magnituide	Residuals
Posted price	100	10.8	24.1	-0.5	1.8	26.1	36.7	1
when $\pi > 0.5$	100	43	3.1	-0.5	1.5	28.8	40.2	-16.1
when $\pi < -0.5$	100	5.1	22.2	1.5	0.3	29	38.1	4.7
Regular price	100	30.7	63.4	2	3.8	–	–	–
when $\pi > 0.5$	100	69.9	18.6	5.4	6.1	–	–	–
when $\pi < -0.5$	100	14.4	76	8.4	1.2	–	–	–

Correlation with Macro Variables

Fraction Explained by Principal Components

- We examine whether fluctuations are driven by common or idiosyncratic shocks.
- We draw the three largest principals among a certain historical time-series of 3-digit code items (around 100) and calculate the fraction explained by them.
- In particular, the frequency of downward regular price changes and the frequency of temporary sales have higher dependence on common shocks.

%	Total (POS inflation rate)	Regular frequency up	Regular frequency down	Regular magnitude up	Regular magnituide down	Sale frequency	Sale magnituide	Residuals
1st principal	11.6	13.8	20.4	13.2	11	19.7	8.3	14.1
1st to 2nd principals	19.4	21.9	32.3	22.1	18.7	29.4	16.4	25.4
1st to 3rd principals	26	29.1	40.6	29.5	24.6	37.2	21	32.4

Correlation with Macro Variables

Aggregate	Total (POS inflation rate)	Regular frequency up	Regular frequency down	Regular magnitude up	Regular magnituide down	Sale frequency	Sale magnituide	Residuals
POS inflation rate	1**	0.66**	0.53**	-0.09	-0.09	-0.06	0.53**	-0.07
CPI inflation rate	0.63**	0.54**	0.36*	-0.37*	0.27	0.02	0.14	-0.19
Unemploy rate	-0.2	-0.37*	-0.12	0.26	-0.24	0.29	0.13	0.16
Hours worked	0.25	0.43**	0.29	0.2	-0.09	-0.36*	-0.36*	-0.24
Industrial production	0.28	0.36*	0.27	-0.12	0.13	-0.02	-0.29	-0.17
Leading index	0.01	0.17	0.14	0.1	0.03	0.08	-0.45**	-0.24
Coincident index	0.28	0.40**	0.32	0.07	0.12	-0.20	-0.36*	-0.22
Lagging index	0.29	0.43**	0.20	-0.30	0.29	-0.42**	-0.11	-0.13
Base money change	0.14	-0.12	0.17	0.29	-0.25	-0.08	0.40*	-0.12
Call rate	0.44**	0.56**	0.43**	-0.25	0.17	-0.41**	-0.29	-0.19
10yr rate	0.26	0.57**	0.16	-0.01	0.04	-0.19	-0.44**	-0.24

** and * represent 5% and 10% significance, respectively. All series are filterd by Baxter-King band pass filter.

- Regular-price frequency components
  - The frequency of upward regular-price revisions is significantly correlated with other macro variables, namely, the unemployment rate, hours worked, the lagging index as well as the call rate and the 10-year rate.
  - When the economy is in a boom, the labor market is tightened and retailers raise their prices by raising the frequency of upward regular-price revisions.
- Sale price components.
  - The frequency of sales is negatively correlated with the lagging index.
  - When the economy is in a boom (recession), the frequency of sales goes down (up). In particular, labor market conditions appear to influence retailers' temporary sale decisions.
  - One rationale is that increased unemployment rates or decreased hours worked reduce the disutility of households from bargain hunting activity, and retailers react to this by raising their sale frequency.

Final Remarks and Future Work

- What drove deflation?
  - Changes in regular price frequency.
  - Macro shocks, in particular, that contracts the labor market.
- Future work needs to address
  - Causality
  - using and refining macroeconomic theory on pricing and macroeconomic policy.