Expected Inflation Regime in Japan

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June 26, 2017

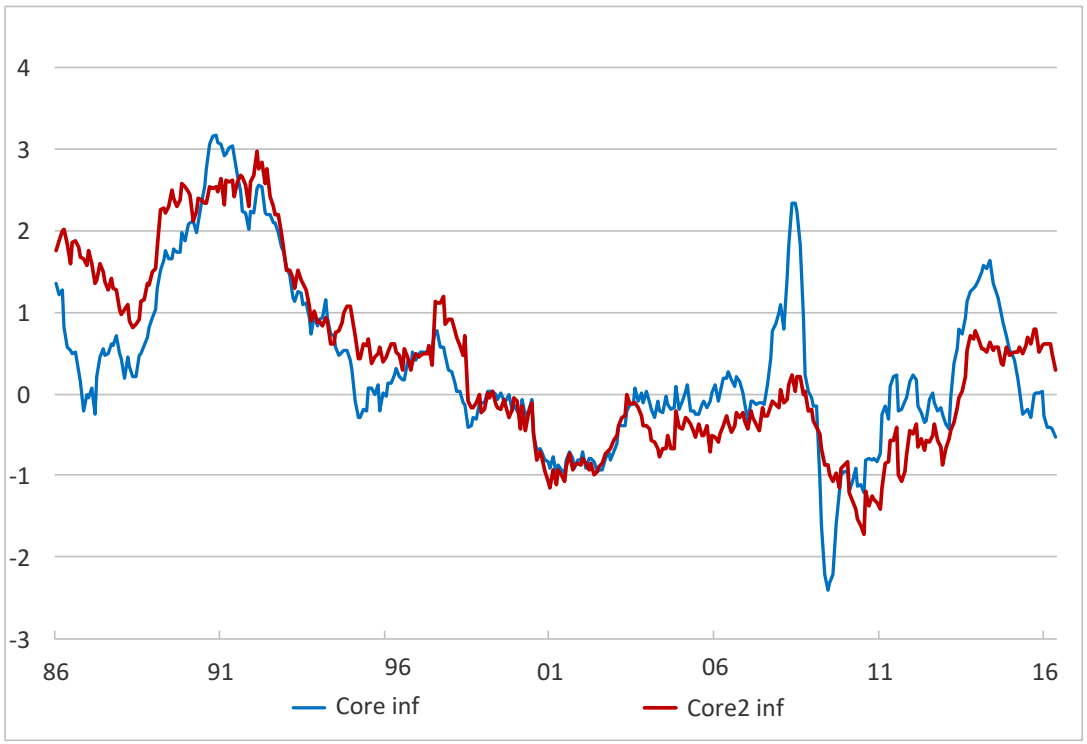
IAAE 2017

Expected Inflation Regime in Japan

1. Inflation is one of the most important variables for macroeconomists and policy makers
2. Inflation affects value of the money
3. Inflation targeting monetary policy is in use by more than 20 countries
4. BoJ introduced 2% inflation target in January 2013 and quantitative and qualitative monetary easing (QQE) in April
5. Instructive to investigate the changes in expected inflation after the introduction of 2% inflation target

Expected Inflation Regime in Japan

6. Japanese inflation regime appears to change several times over the last three decades



7. Identify the regime shifts in expected inflation and their relationship with monetary policy

Addressed Questions

1. How many expected inflation regimes were there over the last three decades in Japan?
2. Is there any relationship between inflation regimes and monetary policy regimes?
3. What were the expected inflation rates under each inflation regime?
4. Has the expected inflation increased after the adoption of the inflation targeting policy by BoJ?
5. Is the current expected inflation significantly different from the BoJ's target of 2%?
6. What are the effects of oil prices, stock prices, and exchange rates on Japanese inflation?

Hybrid Phillips Curve

1. Estimate the expected inflations based on a version of hybrid Phillips curve (Kaihatsu and Nakajima, 2015)

$$\pi_t = \sum_{k=1}^{K} \alpha_k \pi_{t-k} + \left(1 - \sum_{k=1}^{K} \alpha_k\right) \mu_t + \beta_t x_t + \varepsilon_t$$

2. μ_t is an expected inflation component
3. x_t is an output gap
4. KN model μ_t using Markov-switching (MS) model
   1. Stationary MS model can capture only recurrent regime shifts
   2. μ_t will go back to stationary level in the long run
   3. Better to consider permanent regime changes

Smooth Transition (ST) Model

1. Model μ_t using the ST model to capture the possible permanent regime shifts in Japanese inflation
2. Ex. 2 regime ST model

$$\mu_t = \mu^{(1)} + G(s_t; c, \gamma)\left(\mu^{(2)} - \mu^{(1)}\right)$$

3. One of the regime switching models
   1. Regime 1: $G = 0 \Longrightarrow \mu_t = \mu^{(1)}$
   2. Regime 2: $G = 1 \Longrightarrow \mu_t = \mu^{(2)}$

Smooth Transition (ST) Model

4. Regime transition is expressed by a logistic transition function $G(s_t; c, \gamma)$

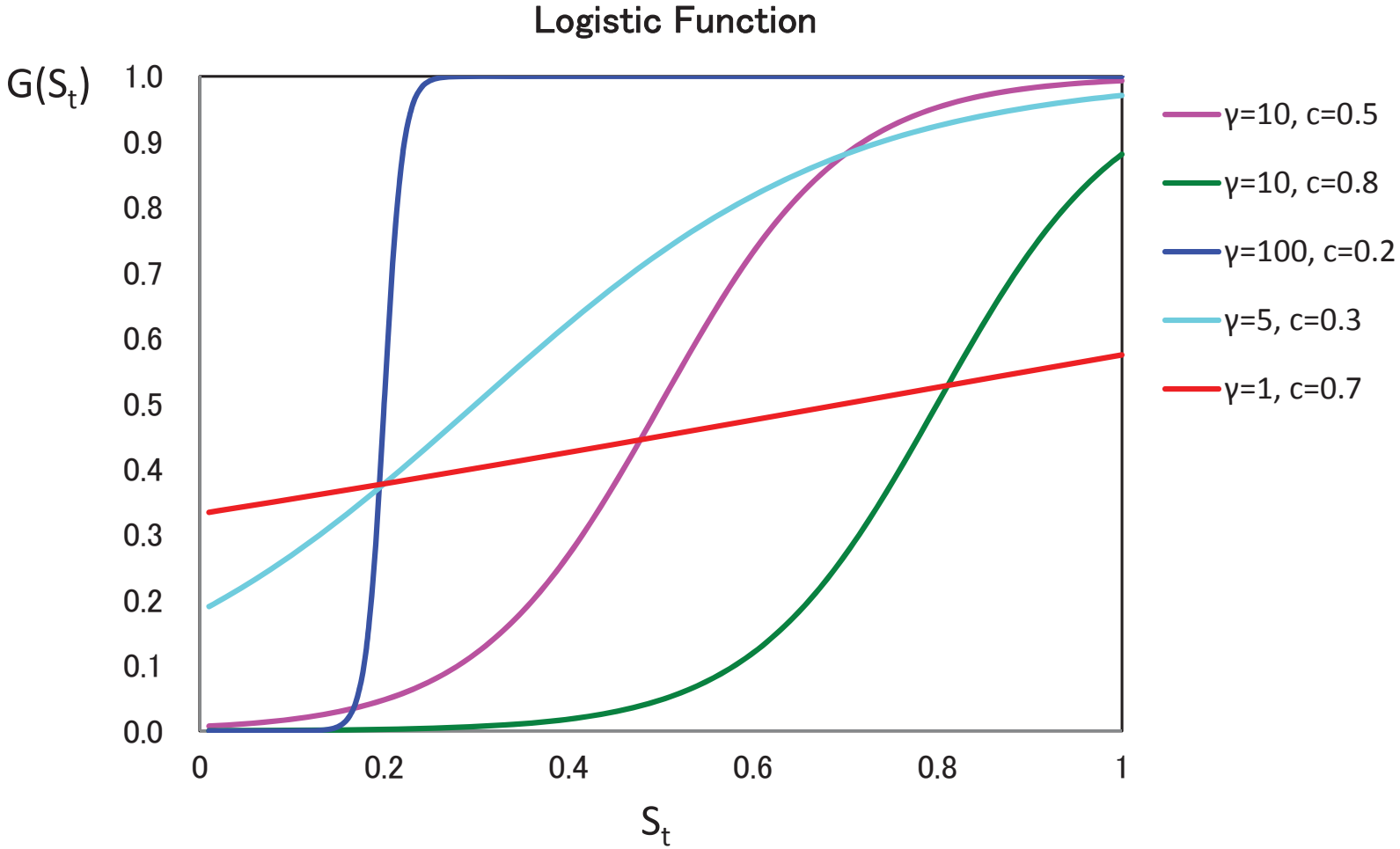
$$G(s_t; c, \gamma) = \frac{1}{1 + \exp(-\gamma(s_t - c))}, \quad \gamma > 0$$

   1. s_t : transition variable
   2. c: location parameter
   3. γ: smoothness parameter

5. Adopt $s_t = t/T$ as a transition variable to capture dominant trends (Lin and Teräsvirta, 1994, JoE)
   1. $\mu^{(1)}$: EI around the beginning of sample
   2. $\mu^{(2)}$: EI around the end of sample

Smooth Transition (ST) Model

6. Can describe a wide variety of patterns of regime transition depending on the values of γ, c



Smooth Transition (ST) Model

7. Can extend to the multiple regime ST model
8. Ex. 3 regime model

$$\begin{aligned}\mu_t &= \mu^{(1)} + G(s_t; c_1, \gamma_1)\left(\mu^{(2)} - \mu^{(1)}\right) \\ &\quad + G(s_t; c_2, \gamma_2)\left(\mu^{(3)} - \mu^{(2)}\right), \quad c_1 < c_2\end{aligned}$$

9. μ_t changes from $\mu^{(1)}$ via $\mu^{(2)}$ to $\mu^{(3)}$ with time
10. γ_i and c_i as well as $\mu^{(i)}$ can be estimated from the data
11. Can estimate the timing and speed of regime changes, and expected inflation level in each regime

Empirical Analysis

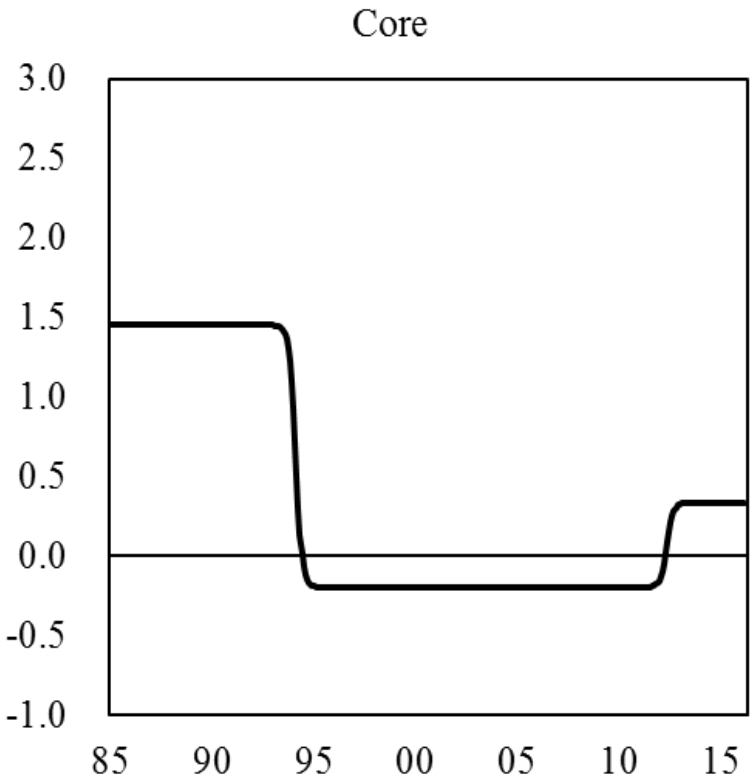
1. Sample period: from January 1985 to July 2016
2. Two inflation measures
   1. Core inflation: exclude fresh food
   2. Core2 inflation: exclude food and energy
3. Output gap is defined by the deviation of industrial production from its HP trend
4. All data are seasonally adjusted
5. Estimate all models by MLE assuming $\varepsilon_t \sim N(0, \sigma^2)$
6. Set $K = 2$ as higher AR terms are not significant in most cases

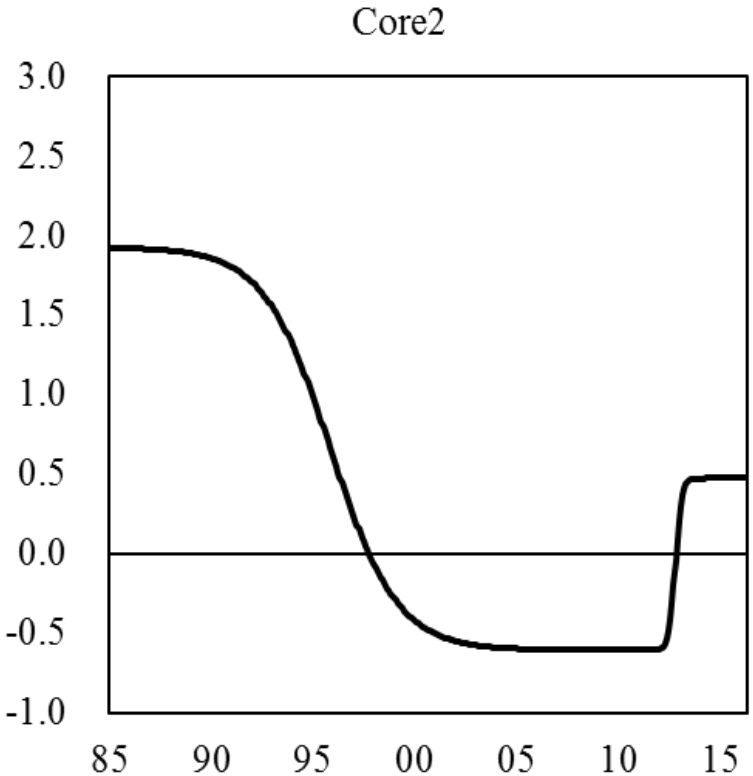
Choice of Number of Regimes

1. How many inflation regimes were there over the last three decades in Japan?
2. Choose the number of regimes by sequential testing (Luukkonen, Saikkonen, and Teräsvirta ,1988, Biometrika, Eitrheim and Teräsvirta, 1996, JoE)
3. There were 2 regimes for core inf and 3 regimes for core2 inf over the last three decades in Japan

Expected Inflation and Monetary Policy Regimes

1. Is there any relationship between inflation regimes and monetary policy regimes?
2. Estimated expected inflation suggests relatively rapid regime changes around 1995 and 2013





Expected Inflation and Monetary Policy Regimes

3. BoJ had conducted the traditional monetary policy using bank rate before 1995
4. BoJ adopted the call rate as the new policy rate in March 1995
5. BoJ started the extremely low interest rate policy with 0.5% call rate in Sep 1995
6. Previous studies detect a regime shift in the effects of Japanese monetary policy around the same timing eg. Miyao (2000, JJIE) and Inoue and Okimoto (2008, JJIE)
7. First regime change seems to coincide with this timing

Expected Inflation and Monetary Policy Regimes

8. BoJ adopted the 2% inflation target in January 2013
9. BoJ introduced the QQE in April 2013
10. Second regime change corresponds to these changes
11. There seems to be strong relationship between the inflation regimes and monetary policy regimes in Japan over the last three decades
    1. 1st regime: Conventional monetary policy regime
    2. 2nd regime: Low interest rate monetary policy regime
    3. 3rd regime: Inflation targeting monetary policy regime

Expected Inflation

1. What was the expected inflation rate under each monetary policy regime?

	Core		Core2	
	Estimate	Std. Error	Estimate	Std. Error
$\mu^{(1)}$	1.452	0.231	1.924	0.156
$\beta^{(1)}$	0.537	0.267	0.623	0.237
$\mu^{(2)}$	-0.195	0.152	-0.605	0.106
$\beta^{(2)}$	0.171	0.135	0.130	0.081
$\mu^{(3)}$	0.338	0.563	0.475	0.215
$\beta^{(3)}$	0.186	0.787	0.001	0.521

Expected Inflation

2. $\mu^{(1)}$ is estimated significantly positively as 1.45% for core and 1.92% for core2
3. $\mu^{(2)}$ is estimated as -0.20% for core, but it is not significantly different from 0
4. $\mu^{(2)}$ is estimated significantly negatively as -0.61% for core2
5. Expected inflation was stable at around 0% or below under the low interest rate monetary policy regime
6. BoJ's policies between 1995 and 2012 were not enough to keep or recover the positive expected inflation

Expected Inflation

7. $\mu^{(3)}$ is estimated as 0.34% for core, but it is not significantly different from 0
8. $\mu^{(3)}$ is estimated significantly positively as 0.48% for core2
9. After BoJ's introduction of the 2 % inflation target with QQE, expected core2 inflation increased rapidly to recover significantly positive expected inflation
10. Null of $\mu^{(3)} = 2$ is rejected at the 5% significant level
11. QQE is partially successful to escape from the deflationary regime, but not sufficient to achieve the 2% inflation target

Extended Phillips Curve

1. Inflation may be affected by other variables than output gap such as oil prices and exchange rates e.g. Hooker (2002), Hara, Hiraki and Ichise (2015)
2. Extended Phillips Curve

$$\begin{aligned}\pi_t &= \sum_{k=1}^{K} \alpha_k \pi_{t-k} + (1 - \sum_{k=1}^{K} \alpha_k)\mu_t + \beta_t x_t \\ &\quad + \delta_t \sum_{j=0}^{2} \Delta o_{t-j} + \xi_t \sum_{j=0}^{2} \Delta e_{t-j} + \theta_t \sum_{j=0}^{2} \Delta r_{t-j} + \varepsilon_t\end{aligned}$$

   1. o: log oil prices
   2. e: log nominal effective exchange rates
   3. r: log TOPIX (Tokyo Stock Price Index)

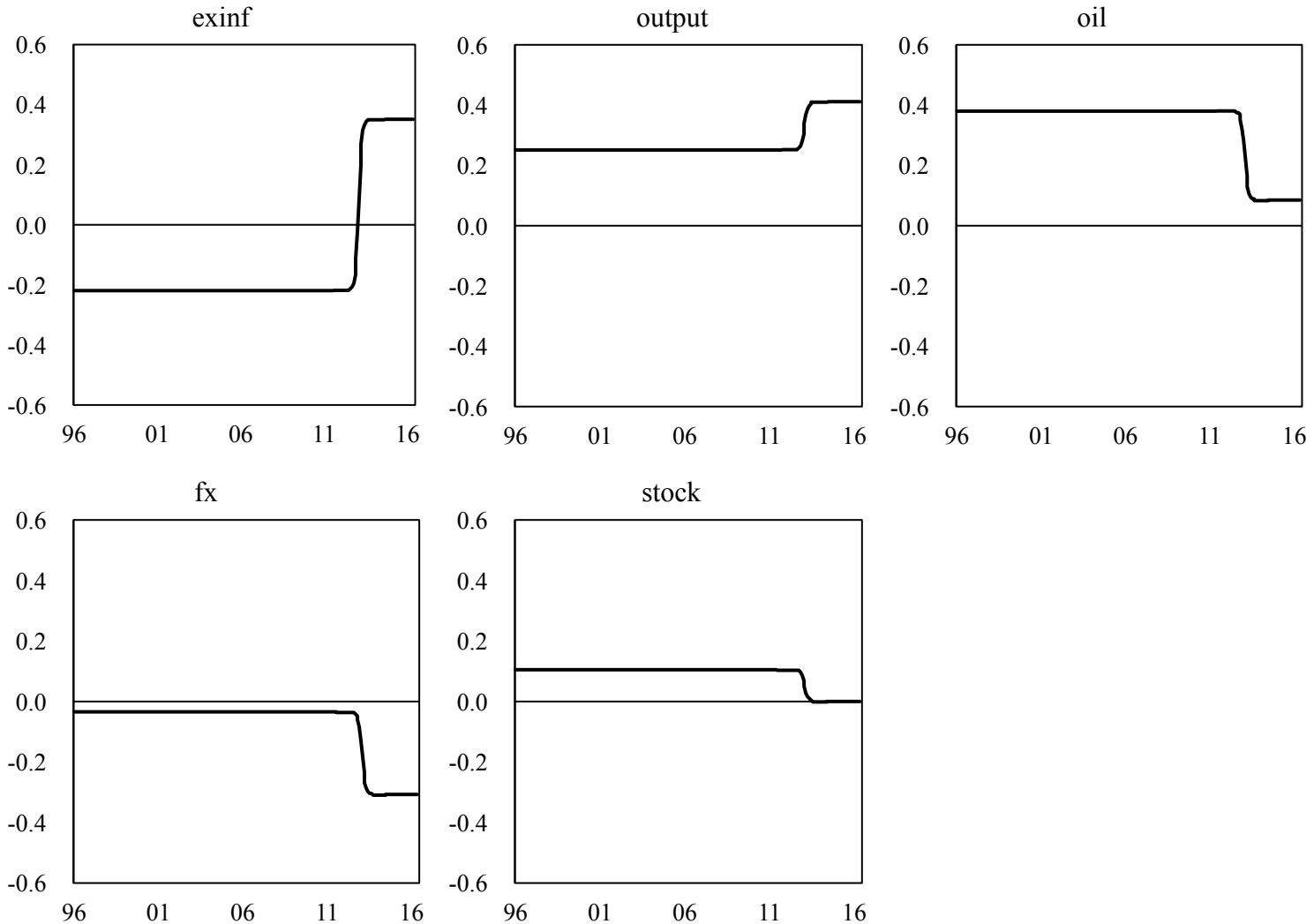
Extended Phillips Curve

3. Unfeasible to estimate the 3-regime ST model
4. Use the data after 1996
5. Assume 2 regimes for each coefficient

$$\delta_t = \delta^{(2)} + G(s_t; c_2, \gamma_2)\left(\delta^{(3)} - \delta^{(2)}\right)$$

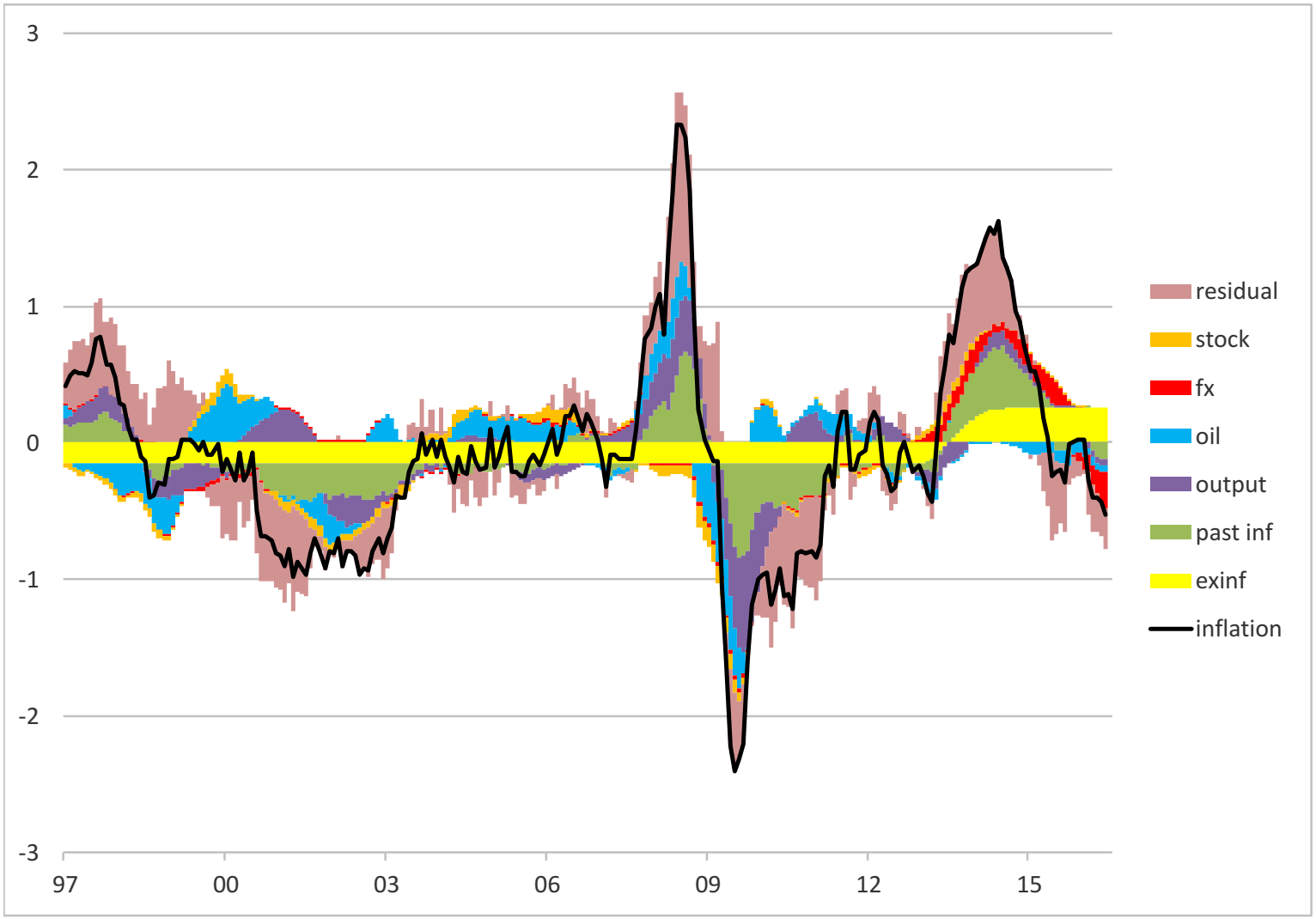
Extended Phillips Curve

6. Coefficient dynamics for the core inflation



Extended Phillips Curve

7. Factor decomposition for the core inflation



Effects on Expected Inflation Regime

1. Examine the effects of oil prices, stock prices, and exchange rates from a different point of view
2. Extend the ST Phillips curve to have multiple transition variables
3. $s_t = (t/T, \sum_{j=1}^{3} \Delta o_{t-j}, \sum_{j=1}^{3} \Delta e_{t-j}, \sum_{j=1}^{3} \Delta r_{t-j})'$

$$G(s_t) = \frac{1}{1 + \exp[-\gamma_T(s_{1t} - c_2) - \gamma_O s_{2t} - \gamma_E s_{3t} - \gamma_R s_{4t}]}$$

4. Assume the expected inflation regimes change according to the transition function with multiple transition variables
5. Use the data after 1996

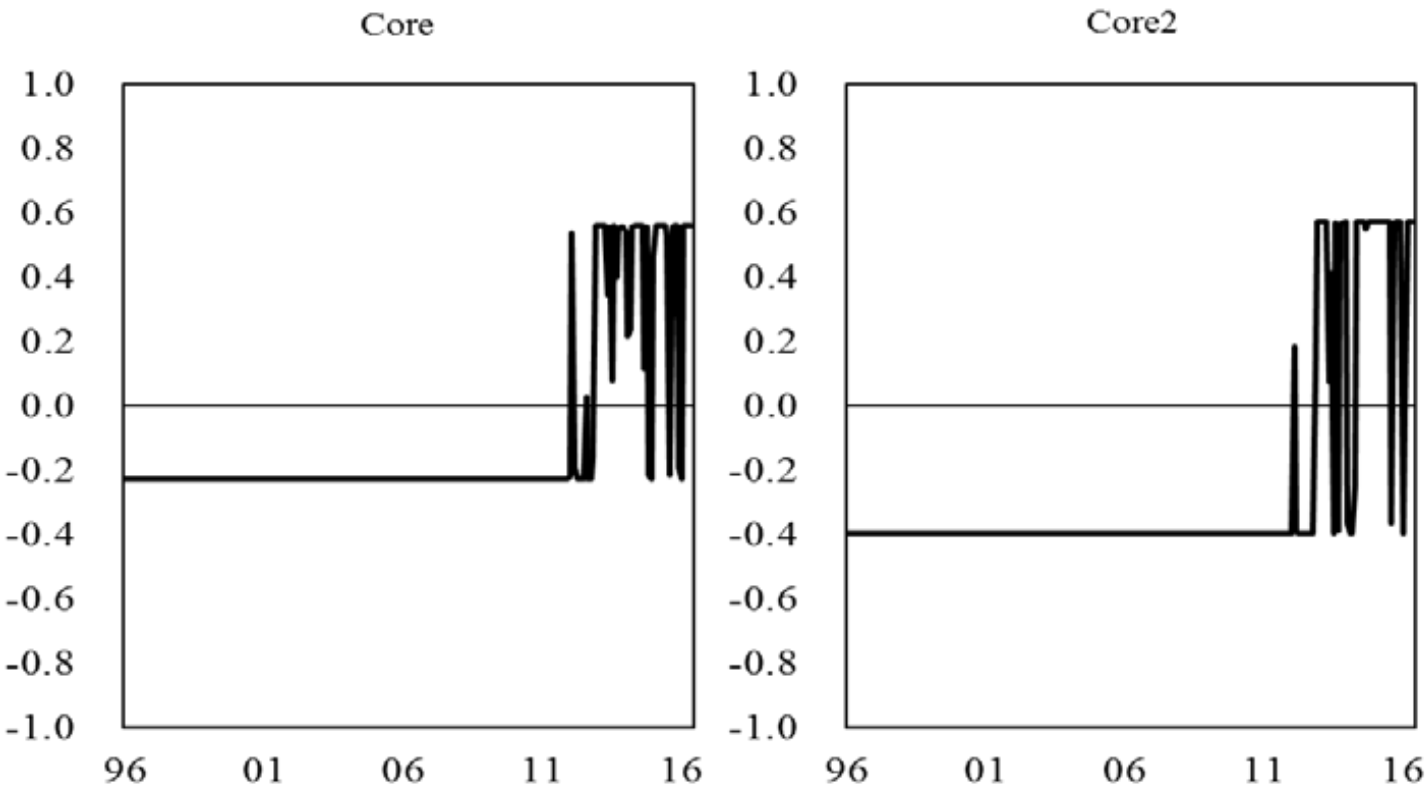
Effects on Expected Inflation Regime

6. Estimation results

	Core		Core2	
	Estimate	Std. Error	Estimate	Std. Error
$\mu^{(2)}$	-0.2290	0.1531	-0.3974	0.0880
$\beta^{(2)}$	0.2272	0.1078	0.1716	0.0833
$\mu^{(3)}$	0.5591	0.4085	0.5719	0.2397
$\beta^{(3)}$	0.7780	0.8287	0.3182	0.9184
γ_T	200	NA	200	NA
c_2	0.8614	0.0116	0.8932	0.0124
γ_O	8.8265	2.8311	0	NA
γ_E	-0.0001	1.0841	-0.9865	3.3808
γ_S	8.1270	3.8458	13.0258	4.7553

Effects on Expected Inflation Regime

7. Estimated expected inflation



8. Recent decline in oil and stock prices may pull back the current inflation regime to deflationary regime

Conclusions

1. There were 2 or 3 inflation regimes over the last three decades in Japan
2. Estimated expected inflation indicates relatively rapid regime changes around 1995 and 2013
3. There seems to be strong relationship between the inflation regimes and monetary policy regimes in Japan over the last three decades
    1. 1st regime: Conventional monetary policy regime
    2. 2nd regime: Low interest rate monetary policy regime
    3. 3rd regime: Inflation targeting monetary policy regime

Conclusions

4. Expected core (core2) inflation was stable at 1.5% (1.9%) until 1993 under the conventional monetary policy regime
5. Expected core (core2) inflation decreased to -0.2% (-0.6%) and remained low under the low interest rate policy regime
6. After BoJ's adoption of inflation targeting monetary policy, expected core (core2) inflation increased rapidly to 0.3% (0.5%)

Conclusions

7. QQE is partially successful to escape from the deflationary regime, but not sufficient to achieve the 2% inflation targeting goal
8. Oil prices and exchange rates play a significant role on the recent inflation dynamics
9. Declines in oil and stock prices may pull back the current inflation regime to the deflationary regime

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