IMES DISCUSSION PAPER SERIES

Determinants of Households' Inflation Expectations

Kozo Ueda

Discussion Paper No. 2009-E-8

IMES

INSTITUTE FOR MONETARY AND ECONOMIC STUDIES

BANK OF JAPAN

2-1-1 NIHONBASHI-HONGOKUCHO

CHUO-KU, TOKYO 103-8660

JAPAN

IMES Discussion Paper Series 2009-E-8
March 2009

Determinants of Households' Inflation Expectations

Kozo Ueda*

Abstract

In this paper, we investigate the determinants of households' inflation expectations in Japan and the United States. We estimate a vector autoregression model in which the four endogenous variables are inflation expectations, inflation, the short-term nominal interest rate and the output gap, with energy prices and (fresh) food prices being exogenous. Short-term nonrecursive restrictions are imposed taking account of simultaneous codependence between realized inflation and expected inflation. We find, first, that responding not only to changes in energy prices and food prices but also to monetary policy shocks, inflation expectations adjust more quickly than does realized inflation. This explains why Japanese and US data indicate that inflation expectations lead realized inflation. Second, the effects of changes in energy prices and food prices on inflation and inflation expectations are large in the short run in Japan, while in the United States, they are not only large but also long lasting. Third, shocks to expectations occasionally fluctuate greatly, and can have self-fulfilling effects on realized inflation. The self-fulfilling property is more apparent in the United States than in Japan.

Keywords: expected inflation; structured vector autoregression; monetary policy
JEL Classification: C32, E31, E52

* Institute for Monetary and Economic Studies, Deputy Director and Economist, Bank of Japan (Email: kouzou.ueda@ boj.or.jp)

The author is grateful to Tatsuyoshi Okimoto, Feng Zhu and other seminar participants at Bank for International Settlements and the Bank of Japan for helpful suggestions. I would also like to thank Ko Nakayama for providing me historical data. Views expressed in this paper are those of the author and do not necessarily reflect the official views of the Bank of Japan. All errors are my own.

1. Introduction

Inflation expectations are important in conducting monetary policy for many reasons. First, their self-fulfilling property causes actual inflation. It is often said that an uncontrollable increase in inflation expectations generated the hyper-inflation of the 1970s. Second, inflation expectations matter because they affect real interest rates, and thereby the real economy and actual inflation. The effect of monetary policy is thus greatly constrained by how expectations are formed. Third, inflation expectations influence wage negotiations between employers and employees. At the same time, inflation expectations are affected by wages, which can induce price–wage spirals. Fourth, uncertainty about expectations discourages real activities and results in inefficient resource allocation. For these reasons, inflation expectations are important for monetary policy. However, little is known about their properties, as Federal Reserve Board chairman Bernanke (2007) states:

> Undoubtedly, the state of inflation expectations greatly influences actual inflation and thus the central bank's ability to achieve price stability. But what do we mean, precisely, by "the state of inflation expectations"? *How should we measure inflation expectations, how should we use the information for forecasting and controlling inflation?* I certainly do not have complete answers to those questions, but I believe that they are of practical importance (emphasis is added in *italic*).

In this paper, we aim to answer Bernanke's second question.[1] We further aim to answer the supplementary questions prompted by the following request by Bernanke (2007):

> … we must understand better the historical variation in inflation expectations, the effect of this variation on actual inflation and economic activity, and the relationship between policy actions and the formation of inflation expectations.

There are a number of empirical studies of the formation of inflation expectations. For example, Carlson and Parkin (1975) argue that past inflation affects inflation expectations. Supposing perfect foresight, Roberts (1998) and Oshima and Nakayama (1999) argue that not only past inflation but also predicted future inflation affects inflation expectations. Mullineaux (1980), Gramlich (1983) and Pearce (1987) examine the effects on inflation

[1] How to measure inflation expectations, which is the first question raised by Bernanke (2007), is beyond the scope of this paper. See Carlson and Parkin (1975) and Berk (2000) for details of the methods used to transform qualitative survey data into quantitative estimates. The papers by Toyoda (1987) and Hirata and Kamada (2006) are available only in Japanese. For the comparisons of inflation expectations among different types of agents, see Gramlich (1983), Batchelor and Dua (1989), Roberts (1998), Oshima and Nakayama (1999), Thomas (1999) and Mankiw et al. (2003). The distribution of inflation expectations is analyzed by Carlson and Parkin (1975), Batchelor and Dua (1989), Mankiw et al. (2003) and Hirata and Kamada (2006).

expectations of government policy and the money supply.

However, to our knowledge, Berk (2000) represents the only attempt to study the effect on inflation expectations of short-term nominal interest rates, which are considered the instrument of monetary policy.[2] His two-step approach can be summarized as follows. First, using data for Europe, he estimates a vector autoregression (VAR) model in which the five variables are the domestic money market rate and its foreign equivalent, the inflation rate, industrial production and the money stock. He then obtains an estimated monetary policy shock from the residual of the interest rate equation in the VAR. Second, he uses a vector error correction model (VECM) of inflation and expected inflation, in which the constructed monetary policy shock is included as an exogenous variable. Berk finds that the monetary policy shock does not have a statistically significant impact on inflation expectations. However, Berk's method seems problematic for two reasons. First, there is no explanation of his identification strategy for the VAR, and the monetary policy shock is unlikely to be properly identified. Second, even if this is not the case, he should have integrated his two-step procedure into one by constructing a five-variable VAR or VECM.

In this paper, to investigate the determinants of inflation expectations, we use a structured VAR (SVAR) model. By using both Japanese and US data, we construct a four-variable VAR in which the endogenous variables are the output gap, the short-term nominal interest rate, realized inflation and inflation expectations. The exogenous variables are energy price changes and (fresh) food price changes. Then, taking account of simultaneous codependence between realized inflation and expected inflation, we impose a nonrecursive restriction to identify structural shocks.

Our analyses shows that, first, responding not only to changes in energy prices and food prices, but also to monetary policy shocks, inflation expectations adjust more quickly than does realized inflation. This explains why Japanese and US data indicate that inflation expectations lead realized inflation. It is also shown that our SVAR procedure resolves the price puzzle; an interest rate rise decreases prices even on impact. Second, in Japan and the United States, changes in energy prices and food prices have large effects on inflation and inflation expectations. However, these are only short-run effects in Japan, while in the United States, they are persistent. Third, shocks to expectations occasionally fluctuate greatly, and may have self-fulfilling effects on realized inflation. The self-fulfilling property is more apparent in the United States than in Japan.

[2] In addition to studies of the effects of short-term nominal interest rates, there are also studies of the effects of other monetary policy instruments. For example, Hori and Shimizutani (2003) analyze a survey that directly asks respondents about the effect on inflation expectations of the quantitative easing of monetary policy implemented from 2001 in Japan. From the perspective of inflation targeting, Orphanides and Williams (2002) and Erceg and Levin (2003) study people's learning processes and their inflation expectations.

This paper is structured as follows. In Section 2, we provide an overview of inflation expectations. In Section 3, we explain our methodology. In Sections 4 and 5, respectively, we report our estimation results for Japan and the United States. In Section 6, we examine the robustness of our results. Section 7 concludes the paper.

2. Overview of Inflation Expectations

Inflation expectations data are divided into two main categories: market-based inflation expectations, which are reflected in Treasury inflation-protection securities, and survey-based inflation expectations. In this paper, we focus on the latter. Table 1 reports the survey-based inflation expectations data that are available in Japan. In the first three surveys, because respondents are households, one can examine inflation expectations from the perspective of the buyers of goods. Of these three surveys, the Consumer Confidence Survey, which began in 1971, covers the longest period. This survey is therefore useful for conducting time-series analysis. However, a major limitation is that its information is qualitative; that is, households are asked if future price changes are expected to be "good (lower)" or "bad (higher)". Thus, one has to transform this qualitative information into quantitative information by using an appropriate procedure, such as that developed by Carlson and Parkin (1975). TANKAN, the fourth survey in the table, is a survey of enterprises. Thus, the answers from retail industries can be used to examine inflation expectations from the perspective of the sellers of final goods. However, this survey is also qualitative. In the final two surveys in the table, respondents are economists. Consensus Forecasts publishes their inflation expectations over horizons of one quarter to ten years, and these expectations are quantitative. However, this information from Consensus Forecasts is only available from 1990, and the respondents are not necessarily experts on the Japanese economy.

In this paper, we focus on *household* inflation expectations. This is done for two reasons. First, households are important economic agents. Their inflation expectations almost certainly influence the real economy through real interest rates and wage negotiations. Moreover, their inflation expectations affect realized inflation by affecting households' consumption demands, and because some are price-setters. Second (as shown subsequently), households' inflation expectations appear to lead realized inflation by one to three quarters. We attempt to explain this finding, which is of particular interest.

Of the available household surveys, we use the Consumer Confidence Survey because it covers the longest period. We construct two types of measures of inflation expectations. One is a diffusion index (DI), which is constructed by assigning scores of 0, 0.25, 0.5, 0.75 and 1, respectively, to respondents' expectations that prices will be "higher", "slightly higher", "no change”, “slightly lower”, and “lower”.[3] The scores are converted into a figure for expected inflation by applying the method developed by Carlson and Parkin (1975), which is the most widely known and used method. This method assumes that respondents report a variable to rise or fall if their evaluation lies above or below a certain threshold; it is also assumed that their answers are symmetric and normally distributed. Furthermore, it is assumed that the average value of past realizations equals the average value of expectations. Given these assumptions, one obtains the threshold value and inflation expectations for each period. For data on prices, we use the Consumer Price Index (CPI) for all goods except fresh food. CPI for all goods except fresh food and 10% trimmed mean CPI are said to show better performances than other core inflation indicators in terms of tracking the underlying trend of inflation and forecasting the future direction of headline inflation (Shiratsuka [2006]). CPI for all goods except fresh food is the most widely used index in Japanese monetary policy analysis.

Figure 1 illustrates the movement of households’ inflation expectations. In the graph, the inflation rate for each period indicates the price change from the previous year. The inflation expectation for each period represents the difference between the current price and the expected future price. We find that realized and expected inflation are highly correlated, and that inflation expectations change more quickly than does realized inflation. Table 2 supports these findings. The correlation between the Carlson−Parkin measure of expected inflation and realized inflation is as large as 0.7, and the expected inflation leads realized inflation by two to three quarters. This finding is confirmed when using data from 1990, when adjusting for the inflationary effect of the consumption tax hikes of April 1989 and April 1997, and whether using the CPI including or excluding food and energy.

Next, we compare the inflation expectations of households with those of retailers and professional economists. Table 3 shows that the lead length of households’ inflation expectations exceeds those of retailers’ and economists’ inflation expectations.

Similar findings apply to the United States. Table 4 summarizes the main surveys of inflation expectations. The Michigan Survey provides households’ inflation expectations, while the Livingston Survey, Survey of Professional Forecasters and Consensus Forecasts provide professional economists’ expectations. In contrast with Japan, all four US surveys are quantitative. Thus, the Carlson−Parkin method is not needed. As Figure 2 and Table 5 show, households’ inflation expectations lead realized inflation for both the CPI and the core PCE deflator by one quarter and three quarters, respectively. Table 6 compares the inflation expectations of households with those of economists. We find that economists’ inflation expectations do not lead realized inflation. These findings are consistent with those of

[3] For some survey periods, the number of choices is three (rather than five), to which we assign scores of 0, 0.5 and 1, respectively.

Thomas (1999).

A question that arises at this stage is why households' inflation expectations change more quickly than does realized inflation. To answer this question, in the following sections, we examine the determinants of households' inflation expectations.

3. Methodology

We use an SVAR to examine the determinants of inflation expectations. We assume that the true model can be written as

$$A_0 X_t = A(L) X_{t-1} + e_t, \quad I_n = E[e_t e'_t], \tag{1}$$

where X_t is a vector of n endogenous variables, A_0 and $A(L)$ are coefficient matrices, and L is the lag operator. The structured shocks, e_t, are assumed to be mutually orthogonal, and their variance−covariance matrix is an $n \times n$ identity matrix. A standard VAR method is described by the following reduced form:

$$X_t = B(L) X_{t-1} + \varepsilon_t, \quad \Sigma = E[\varepsilon_t \varepsilon'_t]. \tag{2}$$

In this case, the obtained shocks, ε_t, are mutually dependent, and thus cannot be regarded as structural. Therefore, one needs to impose restrictions, and identify mutually independent structural shocks that cause the endogenous variables to fluctuate. In general, the number of restrictions needed is $n(n$-$1)/2$.

We impose a nonrecursive restriction. Of the proposed approaches, the simplest is to impose a recursive restriction. This method assigns a certain time ordering to the endogenous variables. It is the most widely used method in macroeconomic studies, particularly for the analyses of monetary policy (see, for example, Sims [1980, 1992], Bernanke and Mihov [1998] and Christiano, Eichenbaum and Evans [1999]). However, applying this method to inflation expectations is inappropriate because inflation expectations affect, and are simultaneously affected by, inflation. Thus, we impose a nonrecursive restriction, as developed by, for example, Kim (1999) and Sims and Zha (2005). This enables us to incorporate the interaction between inflation and inflation expectations and assess the determinants of inflation expectations.

Before moving to our nonrecursive restriction, we explain our VAR specification. We estimate a VAR model that has four endogenous variables. These are the output gap (y), the short-term nominal interest rate (i), the inflation rate from the previous quarter (π) and the current expected inflation rate (π^e). Short-term nominal interest rates are contracted interest rates on loans and discounts (short term and stock) available from the Bank of Japan. We use these data, rather than data on overnight call rates, because the latter had a zero lower bound around 2000. The output gap is calculated by Hara et al. (2006) using a production function approach. The inflation rate is the change in CPI, excluding fresh food, from the previous quarter. Adjustments are made for seasonality and for the effects of consumption taxes. These measures of the output gap and inflation are used because the Bank of Japan appears to assign them the most weight; hence, their use helps us to identify a monetary policy shock. Moreover, CPI excluding fresh food is said to show better performances than other core inflation indicators in terms of tracking the underlying trend of inflation and forecasting the future direction of headline inflation (Shiratsuka [2006]). Inflation expectations are calculated using the Carlson−Parkin method. Inflation expectations are not adjusted for the effect of consumption taxes because it is difficult to identify when and how much households change their inflation expectations responding to announced changes in consumption taxes. We also use the following exogenous variables: oil price changes from the previous quarter (*dPoil*), fresh food price changes from the previous quarter (*dPfresh*) and consumption tax dummies. Fresh food prices are seasonally adjusted. The first two variables have no more than one lag. Oil price data are taken from the Nikkei oil index. Consumption tax dummies take the value unity from 1988:Q4 to 1989:Q1 and from 1996:Q4 to 1997:Q1, and zero otherwise. Our sample period ranges from 1975:Q1 to 2007:Q4.[4] The number of lags selected by the Hannan−Quinn information criterion is two. All data are in logarithms multiplied by 100.

We use a similar VAR specification for the United States, for which the four endogenous variables are the output gap, the federal fund rate, the inflation rate and the expected inflation rate. The output gap is obtained using the Hodrick−Prescott filter. The price index used is core PCE deflator excluding food and energy and is seasonally adjusted. We use these measures of the output gap and inflation because they seem to be assigned the most weight by the Federal Reserve; hence, their use helps us to identify a monetary policy shock. Inflation expectations are the mean of households' one-year-ahead forecasts of inflation, obtained from the Michigan Survey.[5] The two exogenous variables are the change in energy prices (*dPenergy*) and the change in food prices (*dPfood*). Both variables have no more than one lag. Food prices are seasonally adjusted. The sample period ranges from 1970:Q1 to 2007:Q4. The number of lags selected using the Hannan−Quinn information criterion is three.

To find the true structured model, we impose the zero restriction described in equation (3) below. Given the definition $X_t = \{y_t, i_t, \pi_t, \pi_t^e\}'$, the coefficient matrix A_0 in equation (1) is:

$$A_0 = \begin{pmatrix} \mathrm{x} & 0 & 0 & 0 \\ 0 & \mathrm{x} & 0 & \mathrm{x} \\ \mathrm{x} & 0 & \mathrm{x} & \mathrm{x} \\ \mathrm{x} & \mathrm{x} & \mathrm{x} & \mathrm{x} \end{pmatrix}. \tag{3}$$

Because there are four variables, we impose 4(4−1)/2 = 6 zero restrictions. From equation (1),

[4] Data on the output gap are available from 1975:Q1.
[5] We use mean (rather than median) inflation expectations these data are available over a longer period.

imposing this restriction yields:[6]

$$
\begin{aligned}
y_t &= A_1(L)X_{t-1} + e_t^y \\
i_t &= a_1\pi_t^e + A_2(L)X_{t-1} + e_t^i \\
\pi_t &= a_2 y_t + a_3\pi_t^e + A_3(L)X_{t-1} + e_t^p \\
\pi_t^e &= a_4 y_t - a_5 i_t + a_6\pi_t + A_4(L)X_{t-1} + e_t^{pe}.
\end{aligned} \tag{4}
$$

The rationale for this restriction is as follows. The first equation implies that the output gap does *not* respond contemporaneously to the other variables. The corresponding shock is interpreted as a demand shock. As is shown subsequently, this interpretation is justified by looking at the impulse response to a positive demand shock that raises the output gap, inflation and expected inflation. The second equation implies that a central bank *cannot* monitor the current inflation rate or the current output gap, but that it is forward-looking and takes account of households' inflation expectations to proxy its own expectations. The coefficient a_1 is expected to be positive. The corresponding shock is interpreted as an interest rate (monetary policy) shock by the central bank. Third, inflation is *not* contemporaneously responsive to the interest rate because of the lagged effect of monetary policy. This equation is comparable to the New-Keynesian Phillips curve. The coefficients a_2 and a_3 are expected to be positive, and a_3 is expected to be less than unity because of price stickiness. The corresponding shock is interpreted as an unexpected inflation shock. In the fourth equation, no zero restriction is imposed. This is because we aim to identify the determinants of inflation expectations, about which little is known. Another reason is that people are assumed to form their expectations by taking account of all the currently available information. We expect the coefficients a_4, a_5 and a_6 to be positive. The corresponding shock is interpreted as an inflation expectations shock.

In this restriction, we assume simultaneous interactions between inflation expectations and inflation and between inflation expectations and the interest rate. The inflation expectations shock contemporaneously and indirectly affect inflation and the interest rate, because in the second and third equations, the inflation expectations shock contemporaneously influence inflation expectations, and in turn, inflation and the interest rate. In an opposite direction, there is a feedback from inflation and the interest rate to inflation expectations. Such simultaneous interactions are intrinsic to nonrecursive restrictions (Kims [1999] and Sims and Zha [2005]). For example, Kim (1999) uses the world export commodity price index instead of inflation expectations, and imposes a nonrecursive restriction that has a simultaneous interaction between the world export commodity price index and the interest rate. He then identifies five structural shocks including the monetary

[6] For simplicity, we omit the exogenous variables from this expression.

policy shock, and studies the contribution of the structural shocks to output fluctuations.

4. Estimation Results (Japan)

4.1 Estimated Coefficients

From the estimated reduced-form VAR, the coefficients, a_1 to a_6, are derived as shown in Table 7. To compute the corresponding confidence intervals, we use the Monte-Carlo simulations of 10,000 draws based on the following distribution for the reduced-form parameters and covariance matrix

$$vec(B) \sim N[vec(\hat{B}), \Sigma \otimes (X'X)^{-1}]$$
$$\Sigma \sim IW[(T\hat{\Sigma})^{-1}, T-p],$$

where $\hat{B}$ and $\hat{\Sigma}$ are the estimated parameters and covariance matrix, $N[]$ denotes the normal distribution, $IW[]$ denotes the inverted Wishart distribution, and p and T are the number of explanatory variables and observations, respectively. By using the covariance matrix from each draw, we calculate the coefficients a_1 to a_6 and sum them up to yield the figures reported in Table 7.[7]

As expected, all coefficients are positive except for a_3, which is insignificant. This validates our VAR restrictions.

4.2 Impulse Responses

Figure 3 illustrates the impulse responses of the four endogenous variables to four structural shocks. Each column represents a structural shock whose magnitude is one standard error, and each row represents the responses of the endogenous variables. Solid lines represent the means, and dotted lines represent the 16th and 84th percentiles.

The first column shows that a positive shock increases the output gap, inflation, inflation expectations and the interest rate. Thus, this shock is interpreted as the demand shock. The second column shows the responses to a positive interest rate shock in the monetary policy. A rise in interest rates causes the output gap and inflation expectations to decrease on impact. Inflation decreases on impact, too. This result suggests that the price puzzle is resolved because we use the data of inflation expectations for estimation and we impose the nonrecursive restriction described as equation (3). We also find that inflation expectations respond more quickly than does inflation. This result suggests that there is price stickiness and that households correctly forecast the future direction of price changes following a monetary policy shock. The response of inflation on impact is not large, but is persistent. The

---

[7] Because of nonrecursive restrictions, in the Monte-Carlo simulation, we did not always obtain finite coefficients. In such cases, we took another draw. For this and subsequent estimations, the probability of having to redraw was about 10% to 30%.

third column suggests that a positive inflation shock raises inflation, and thereby interest rates, but its impact on inflation expectations is small. Output decreases. Therefore, this shock resembles a negative supply shock. The fourth column illustrates the responses to a positive inflation expectations shock. Such a shock raises inflation expectations on impact, and this increase is accompanied by an increase in interest rates. However, its effect on inflation is insignificant. To sum up, these impulse responses appear reasonable, which validates our VAR restrictions.

Figure 4 illustrates the impulse responses of the four endogenous variables to one-standard-error changes in the exogenous variables. Inflation expectations promptly react to changes in oil prices and fresh food prices. These effects are transitory. Realized inflation reacts relatively slowly to changes in oil prices and fresh food prices, but these effects are persistent. The slow response of inflation to fresh food prices is partly explained by the fact that our price index excludes fresh food.

In summary, these results suggest that households' inflation expectations lead realized inflation because households' expectations react to both monetary policy changes and changes in oil prices and fresh food prices more quickly than does realized inflation. This reflects the sluggish response of realized inflation to expected inflation.

4.3 Variance Decompositions

Table 8 reports variance decompositions showing the contributions made by structural shocks and exogenous variables to the forecast error variances of realized and expected inflation at horizons of 1, 4, 8 and 20 quarters.[8]

This table shows, first, that the exogenous variables have large short-run effects on realized and expected inflation. Their contribution is almost 30% at horizons of 1 and 4 quarters. However, their effects are not persistent.[9] Our second finding is that the monetary policy shock has a large effect. The contribution of the monetary policy shock to expected inflation is about 60% in the short run. Its contribution to inflation is negligible in the short run probably because of price stickiness, but increases to 30% within two to five years. Third, the contribution of the demand shock to realized and expected inflation is smaller than 15% at horizons of 1 and 4 quarters, but larger than 50% at a horizon of 20 quarters. Fourth, the inflation expectation shock has a limited effect. These findings suggest that changes in

---

[8] Because there is apparently no conventional way to calculate the contribution of the exogenous variables, we simply add their one-standard-error deviations to our VAR model, while we add one-standard-error deviations of the structural shocks to calculate the contribution of the structural shocks. This method would be accurate if the exogenous variables were white noise. In our model, because we use changes in (rather than levels of) the exogenous variables, our exogenous variables are stationary and not strongly autocorrelated.

[9] The contribution of fresh food prices to realized inflation is still about 30% at a horizon of 8 quarters. This is largely caused by the sample of the 1970s.

realized inflation are largely caused by changes in oil prices and fresh food prices in the short run, but in the medium to long run, are mainly changed by fundamentals such as output and monetary policy. This is consistent with Shiratsuka (2006). The same result is applied to changes in expected inflation. The second and fourth of these findings for Japan differ from those for the United States (see Section 5).

4.4 Structural Shocks

Figure 5 shows the historical movements of the two structural shocks, the inflation shock and the expected inflation shock. The most notable and interesting property is that the inflation expectation shock is occasionally unstable. During the oil price shocks of the 1970s and early 1980s, and during the asset price bubble and burst of the late 1980s and the early 1990s, the expectation shock exhibited large fluctuations. This implies that an expectation shock occasionally affect inflation and the real economy. In the late 1990s and early 2000s, there were concerns about a deflationary spiral, but the figure does not justify these concerns. Up until the early 1980s, when the inflation shock was stabilized, there were large swings in the inflation shock.

5. Estimation Results (the United States)

In this section, we report our estimation results for the United States. We also confirm that our methodology is validated by the US data. Table 9 shows that, as expected, all the estimated coefficients are positive except for a_2, which is insignificant. The coefficient a_3 lies between zero and unity, which suggests price stickiness and that households are forward-looking. The coefficient a_6 is positive but insignificant.

Figures 6 and 7 illustrate the impulse responses. They show that inflation expectations respond quickly to a monetary policy shock. Exogenous changes in energy prices and food prices affect inflation with a lag, but inflation expectations react quickly to changes in these prices. These results are consistent with those for Japan, and explain why inflation expectations lead realized inflation. An interesting difference between the US and Japanese results is that realized inflation reacts significantly to an inflation expectations shock in the United States. This implies that, in the United States, expectations shocks are self-fulfilling.

Table 10 reports the variance decompositions, which convey the effects of monetary policy shocks. For all time horizons, their contribution to inflation expectations amounts to about 50%. The fact that the contribution of a monetary policy shock to realized inflation increases to up to 40% as the time horizon lengthens reflects price stickiness. The exogenous variables (changes in energy prices and food prices) have large effects, with contribution reaching about 20%. A contrast with Japan is that the effects are persistent in the United States but only transitory in Japan. This may explain why Japan experienced sharper disinflation in the 1980s than did the United States. Table 10 also shows that expectations shocks account for about 10% variations in inflation and inflation expectations. This is twice as large as the corresponding contribution for Japan.

Figure 8 illustrates the movements of two structural shocks, namely, the inflation shock and the inflation expectations shock. The inflation shock exhibited large fluctuations during the two periods of the oil price shocks, since when it gradually stabilized. The inflation expectations shock was particularly volatile during the period of the second oil price shock.

6. Robustness

6.1 Japan

Figures 9 to 18 examine the robustness of our estimates in different ways. First, we look at Japan. In addition to our baseline sample, 1975:Q1~2007:Q4, we use different samples, that is, 1975:Q1~1989:Q4, 1984:Q1~2007:Q4, and 1975:Q1~1999:Q1. The first two samples divide our full sample into early and late subperiods. The third sample ends in 1999:Q1, when the Bank of Japan lowered its policy interest rate to almost zero. Figure 9 shows that our estimates are quite robust. However, for the 1975:Q1~1989:Q4 sample, the monetary policy shock does not seem to be properly identified, judging from the observation that inflation rises following a positive interest rate shock. Figure 10 shows that if the estimating sample starts at 1983:Q1, the effects of the exogenous variables on inflation diminish. This is consistent with inflation having become more stable since the early 1980s. However, it is worth noting that the effects of the exogenous variables on inflation expectations have not changed much.

Second, we estimate our model by extending the number of lags from two to four, using the computed output gap obtained from applying Hodrick−Prescott filter,[10] and excluding the exogenous variables. Figure 11 shows that our results are robust to these modifications.

Third, we impose the SVAR restrictions shown in Figure 12. Under the first restriction (identification restriction 1), in equation (4), we allow the current output gap to be affected by the current change in inflation expectations. Under the second restriction (identification restriction 2), we allow the interest rate to respond not only to inflation expectations but also to current inflation. That is, we relax the zero restriction on π^e in the *y* equation and the zero restriction on π in the *i* equation. However, because we had to impose exactly six restrictions to identify four structural shocks, we must introduce an additional restriction. To do so, we assume that current inflation is *not* affected by current output. Figure 12 demonstrates that imposing these identification restrictions does not change our results much. However, imposing the identification restriction 2 speeds up the response of inflation to a

[10] Rather than using the conventional smoothness factor $\lambda = 1{,}600$, we used $\lambda = 20{,}000$ because this value generates cyclicality that is better suited to Japanese business cycles.

monetary policy shock, compared with our baseline model. If we impose a recursive restriction on the ordering of (y, π, i, π^e) from the exogenous variables (which seems to be the most reasonable ordering), then the impulse responses change dramatically (identification restriction 3). However, this restriction does not seem appropriate because, as the second column shows, a positive interest rate shock increases both inflation and expected inflation. This suggests that such a recursive restriction cannot be imposed to correctly identify a monetary policy shock.

Fourth, we examine the robustness of our estimates to using different measures of inflation expectations. In transforming qualitative survey data into quantitative inflation expectations, we used the simplest and most widely used method, developed by Carlson and Parkin (1975). However, as shown in Figure 13, there are many variations to this method. For example, Hirata and Kamada (2006) adjust the method to correct for an upward bias that seems intrinsic to households' inflation expectations. This adjustment yields much lower inflation expectations than ours for the whole sample period. Having argued that survey questions relate to changes in inflation rates rather than to changes in prices, Toyoda (1987) calculates inflation expectations by using realized inflation rates for each period. This method generates inflation expectations that are similar to realized inflation rates. We reestimate the SVAR by using these alternative measures of inflation expectations. As Figure 14 shows, the resulting impulse responses are similar to those from our baseline model. However, because of strong correlation with realized and expected inflation, using Toyoda's (1987) inflation expectations causes the responses of inflation and expected inflation to be similar to each other.

Fifth, we estimate the VAR in levels. We use real GDP instead of the output gap, price levels instead of inflation rates, and expected prices, that is, price levels multiplied by inflation expectations, instead of expected inflation rates. We impose the same nonrecursive restrictions as before. Figure 15 illustrates that our estimates are robust to this modification.

6.2 The United States

For the United States, Figures 16 and 17 illustrate the impulse responses for the two subperiods. Although the figures are similar, the effects of the monetary policy on inflation and inflation expectation are slightly larger in the 1970:Q1~1983:Q4 period than in the 1984:Q1~2007:Q4 period. The same is true for the effects of the exogenous variables on inflation and inflation expectations.

Figure 18 illustrates the impulse responses produced by increasing the number of lags from two to four, excluding the exogenous variables, and using the CPI instead of the core PCE deflator. Our results are robust to these modifications.

7. Concluding Remarks

In this paper, we investigate the determinants of households' inflation expectations in Japan and the United States. We estimate a vector autoregression in which the four endogenous variables are inflation expectations, inflation, the short-term nominal interest rate and the output gap, with changes in energy prices and (fresh) food prices being the exogenous variables. We impose short-term nonrecursive restrictions taking account of the simultaneous co-dependence between realized inflation and expected inflation.

Our findings can be summarized as follows. First, responding not only to changes in energy prices and food prices but also to monetary policy shocks, inflation expectations move more quickly than does realized inflation. This explains why inflation expectations appear to lead realized inflation according to Japanese and US data. It is also shown that our SVAR procedure resolves the price puzzle; an interest rate rise decreases prices even on impact. Second, in Japan and the United States, changes in energy prices and food prices have large effects on inflation and inflation expectations. However, in Japan, these effects are transitory, whereas in the United States, they are persistent. Third, expectations shocks occasionally fluctuate greatly, and could have self-fulfilling effects on realized inflation. This self-fulfilling property is more apparent in the United States than in Japan.

In implementing monetary policy, we need to forecast underlying inflation, and our findings suggest that expected inflation is a useful indicator. However, since the effects of energy prices and food prices on realized and expected inflation are only temporary, it is practically very important to adjust these effects and extract underlying expected inflation movements caused by fundamentals such as changes in output and interest rates. It is also important to pay attention to the risk that inflation expectations fluctuate greatly and have self-fulfilling effects on realized inflation.

To investigate the properties of inflation expectations in more detail, we may need to subject our estimates to further robustness checks. This may include imposing other restrictions, making international comparisons and refining the time-series analysis. Although we focused on households, it is important to analyze firms and professionals. It is also important to study long-term inflation expectations. These are our future research tasks.

References

Batchelor, R.A. and P. Dua (1989), "Household versus economist forecasts of inflation: A reassessment," *Journal of Money, Credit and Banking*, 21(2), 252−257.

Berk, J.M. (2000), "Consumers' inflation expectations and monetary policy in Europe," *De Nederlandsche Bank Working Paper*.

Bernanke, B.S. (2007), "Inflation expectations and inflation forecasting," Remarks at the NBER Monetary Economics Workshop.

Bernanke, B.S. and I. Mihov (1998), "Measuring monetary policy," *Quarterly Journal of Economics*, 113, 869−902.

Carlson, J.A. and M. Parkin (1975), "Inflation expectations," *Economica*, 42, 123−138.

Christiano, L.J., M. Eichenbaum and C.L. Evans (1999), "Monetary policy shocks: what have we learned and to what end?" in J.B. Taylor and M. Woodford (eds.), *Handbook of Macroeconomics* Vol.1A, Amsterdam: Elsevier Science, 65−178.

Erceg, C.J. and A.T. Levin (2003), "Imperfect credibility and inflation persistence," *Journal of Monetary Economics*, 50, 915−944.

Gramlich, E.M. (1983), "Models of inflation expectations formation: A comparison of household and economist forecasts," *Journal of Money, Credit and Banking*, 15(2), 155−173.

Hara, N., N. Hirakata, Y. Inomata, S. Ito, T. Kawamoto, T. Kurozumi, M. Minegishi and I. Takagawa (2006), "The new estimates of output gap and potential growth rate," *Bank of Japan Review*, E−3.

Hirata, W. and K. Kamada (2006), "Measuring inflation expectations with a bias in survey data," mimeo.

Hori, M. and S. Shimizutani (2003), "What changes deflationary expectations? evidence from Japanese household-level data," *ESRI Discussion Paper Series*, No.65.

Kim, S. (1999), "Do monetary policy shocks matter in the G-7 countries? Using common identifying assumptions about monetary policy across countries," *Journal of International Economics*, 48, 387−412.

Mankiw, N.G., R. Reis, and J. Wolfers (2003), "Disagreement about inflation expectations," *NBER Macroeconomic Annu*al, 209−248.

Mullineaux, D.J. (1980), "Inflation expectations and money growth in the United States," *American Economic Review*, 70(1), 149−161.

Oshima, I. and K. Nakayama (1999), "On inflation expectations," *Bank of Japan Working Paper Series*, 99−7 (in Japanese).

Orphanides, A. and J.C. Williams (2002), "Imperfect knowledge, inflation expectations, and monetary policy," *FRB San Francisco Working Paper*.

Pearce D.K. (1987), "Short-term inflation expectations: Evidence from a monthly survey: note," *Journal of Money, Credit and Banking*, 19(3), 388−395.

Roberts, J.M. (1998), "Inflation expectations and the transmission of monetary policy," *FRB Working Paper*.

Shiratsuka, S. (2006), "Core Indicators of Japan's Consumer Price Index," *Bank of Japan Review*, E-7.

Sims, C.A. (1980), "Macroeconomics and reality," *Econometrica*, 48, 1−48.

Sims, C.A. (1992), "Interpreting the macroeconomic time series facts: the effects of monetary policy," *European Economic Review*, 36, 975−1000.

Sims, C.A. and T. Zha (2005), "Does monetary policy generate recessions?" *mimeo*.

Thomas, L.B.Jr. (1999), "Survey measures of expected U.S. inflation," *Journal of Economic Perspectives*, 13(4), 125−144.

Toyoda, T. (1987), "Inflation: formation of inflation expectations and the Phillips curve," in K. Hamada et al. (eds.) *Macroeconomic analysis of the Japanese economy*, Tokyo-daigaku-shuppankai, 287−311 (in Japanese).

Name	Respondents	Organization	Start date	Description
Consumer Confidence Survey	Households (about 5,000 cases; about 75% response rate)	Cabinet Office	1971 (qualitative, quarterly) 2004 (quantitative, monthly)	• Price changes in the following year (or six months depending on the surveyed periods) • Three (or five) qualitative choices until 2004 and seven quantitative choices from 2004. • Quarterly until 2004, monthly from 2004
Opinion Survey on the General Public's Views and Behavior	Households (about 4,000 cases; about 50% response rate)	Bank of Japan	1999 (qualitative) 2004 (quantitative)	• Price changes in the following one and five years • Quarterly
Consumer Sentiment Index Survey	Households (about 1,200 responses)	Nippon Research Institute	1980	• Price changes in the following year • Three qualitative choices • Every two months
TANKAN	Enterprises (about 10,000 cases including 700 retailers; about 100% response rate)	Bank of Japan	1974 (no data in March 1975)	• Output price changes in the following three months • Three qualitative choices • Quarterly
ESP Forecast Survey	36 economists who work in Japan (May 2007)	Economic Planning Association	2004	• Inflation rates in the following one quarter to two years • Monthly
Consensus Forecasts	More than 240 economists in the G7 and Western countries	Consensus Economics	1991	• Inflation rates in the following one quarter to ten years • Quarterly, but long-term forecasts are semiannual.

Table 1: Surveys of Inflation Expectations (Japan)

Quarters (leads of inflation expectations)					
0	0.54	0.54	0.57	0.55	0.55
1	0.65	0.65	0.60	0.66	0.65
2	0.69	0.69	**0.61**	0.70	0.68
3	**0.72**	**0.71**	0.58	**0.71**	**0.70**
4	0.71	0.71	0.53	0.70	0.68
Sample	1971:Q1–2007:Q4	1971:Q1–2007:Q4	1990:Q1–2007:Q4	1971:Q1–2007:Q4	1971:Q1–2007:Q4
CPI coverage	Excl. fresh food	Excl. fresh food	Excl. fresh food	All	Excl. food and energy
CPI Consumption tax	nonadjusted	adjusted	nonadjusted	nonadjusted	nonadjusted

Table 2: Correlations between Inflation and Inflation Expectations (Japan)

Note: Yellow highlights represent the highest correlation.

	Respondents		
Quarters (leads of inflation expectations)	Households	Retailers	Economists
0	0.54	0.83	**0.83**
1	0.65	**0.83**	0.74
2	0.69	0.83	0.62
3	**0.72**	0.81	0.42
4	0.71	0.74	0.27
Sample	1971:Q1−2007:Q4	1975:Q2−2007:Q4	1991:H2−2007:H1 (semiannual)
Survey source	Consumer Confidence Survey (Carlson−Parkin method)	TANKAN (Retailers, DI)	Consensus Forecasts (next year forecasts)
CPI coverage	Excl. fresh food	Goods excl. fresh food	Excl. fresh food
CPI consumption tax	non-adjusted	adjusted	nonadjusted

Table 3: Comparison of Inflation Expectations Surveys
in terms of Correlation with Inflation (Japan)

Name	Respondents	Organization	Description
Survey of Consumers (Michigan Survey)	Households (500 telephone interviews)	University of Michigan	• Price changes in the following year • Quantitative • Quarterly
Livingston Survey	About 40 economists	FRB Philadelphia	• CPI and PPI changes in the following six months to ten years • Quantitative • Semi-annual
Survey of Professional Forecasters	About 50 economists	FRB Philadelphia	• CPI and PCE deflator changes in the following year and in the long run • Quantitative • Quarterly
Consensus Forecasts	More than 240 economists in G7 and Western countries	Consensus Economics	• Inflation rates in the following one quarter to ten years • Quarterly, but long-term forecasts are semiannual.

Table 4: Surveys of Inflation Expectations (the United States)

Quarters (leads of inflation expectations)				
0	0.92	0.82	**0.79**	0.63
1	**0.94**	0.87	0.71	**0.64**
2	0.93	0.90	0.63	0.60
3	0.90	**0.91**	0.46	0.54
4	0.83	0.89	0.21	0.51
Sample	1971:Q1−2007:Q4	1971:Q1−2007:Q4	1990:Q1−2007:Q4	1990:Q1−2007:Q4
Price index	CPI	Core PCE	CPI	Core PCE

Table 5: Correlations between Inflation and Inflation Expectations (the United States)

	Respondents	
Quarters (leads of inflation expectations)	Households	Economists
0	0.92	**0.91**
1	**0.94**	0.86
2	0.93	0.75
3	0.90	0.61
4	0.83	0.48
Sample	1971:Q1−2007:Q4	1971:H1−2007:H2 (semiannual)
Survey source	Michigan Survey	Livingston Survey
Price index	CPI	CPI

Table 6: Comparison of Inflation Expectations Surveys
in terms of Correlation with Inflation (the United States)

	Coefficients		
	5%	median	95%
a_1	0.29	1.32	14.03
a_2	0.00	0.13	0.25
a_3	−0.19	−0.03	0.06
a_4	0.25	1.09	3.99
a_5	3.08	8.07	27.22
a_6	1.07	2.30	7.69

Table 7: Estimated Coefficients (Japan)

(1) Inflation Rate

	e_y	e_i	e_p	e_pe	dPoil	dPfresh
T = 1	1.3	0.2	55.0	0.0	42.7	0.8
T = 4	2.0	4.8	59.5	0.2	6.3	27.3
T = 8	4.0	25.3	42.5	1.9	2.8	23.6
T = 20	57.9	31.3	2.5	3.7	2.1	2.4

(2) Inflation Expectations

	e_y	e_i	e_p	e_pe	dPoil	dPfresh
T = 1	0.2	62.8	0.4	2.3	31.5	2.9
T = 4	12.9	80.6	3.2	1.3	0.1	1.9
T = 8	48.5	44.4	3.2	0.4	1.1	2.4
T = 20	78.3	11.8	0.8	5.0	3.8	0.3

Table 8: Variance Decompositions (Japan)

	Coefficients		
	5%	median	95%
a_1	1.22	3.09	11.28
a_2	−0.05	−0.01	0.03
a_3	0.06	0.12	0.17
a_4	0.30	0.88	6.91
a_5	0.60	2.00	17.44
a_6	−1.08	0.80	5.68

Table 9: Estimated Coefficients (the United States)

(1) Inflation Rate

	e_y	e_i	e_p	e_pe	dPenergy	dPfood
T = 1	0.0	7.8	86.6	2.3	0.1	3.2
T = 4	3.8	20.5	23.1	17.5	6.6	28.4
T = 8	17.3	24.7	3.5	13.8	14.1	26.6
T = 20	7.4	43.5	0.7	13.4	17.7	17.3

(2) Inflation Expectations

	e_y	e_i	e_p	e_pe	dPenergy	dPfood
T = 1	1.1	38.9	0.0	13.4	9.6	37.0
T = 4	24.5	31.0	0.2	6.1	17.0	21.3
T = 8	2.4	47.6	1.7	8.2	20.3	19.8
T = 20	0.0	60.8	7.8	1.8	16.5	13.1

Table 10: Variance Decompositions (the United States)

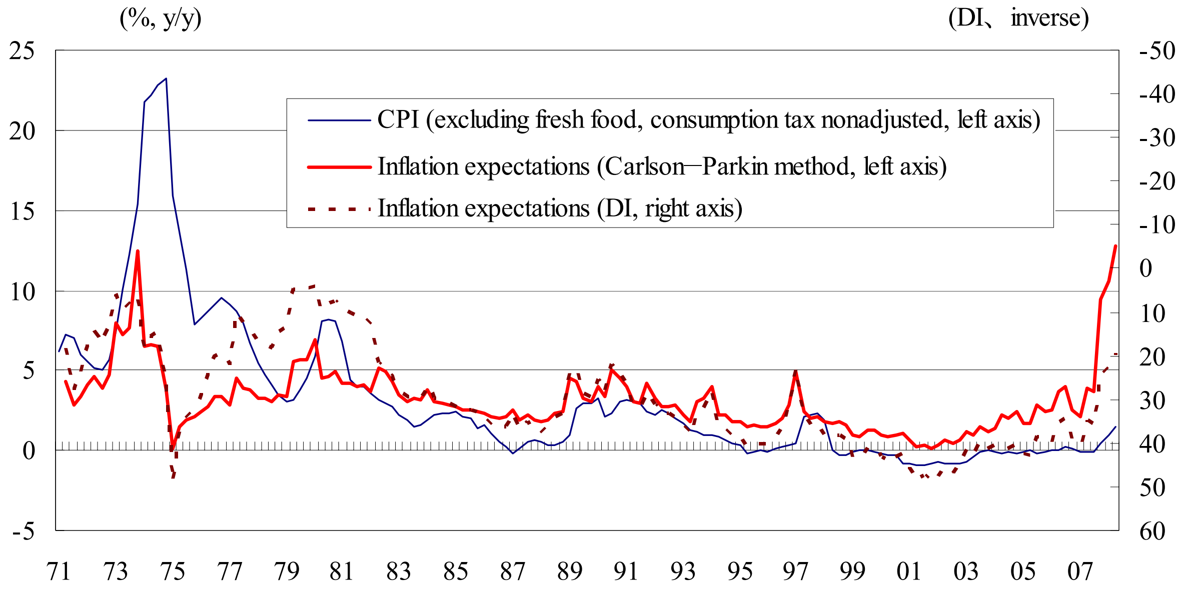

Figure 1: Movement of Inflation Expectations (Japan)

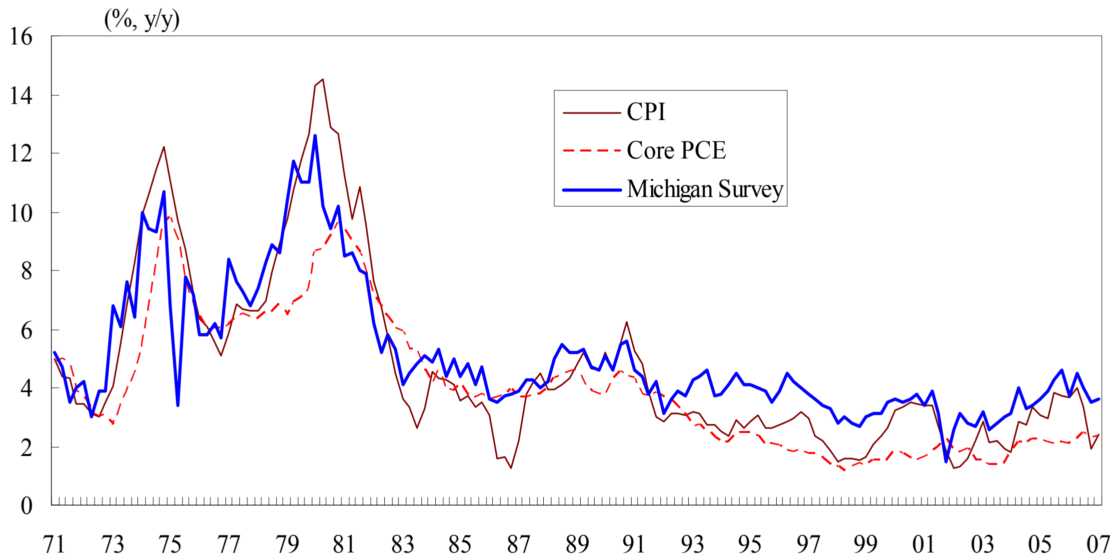

Figure 2: Movement of Inflation Expectations (the United States)

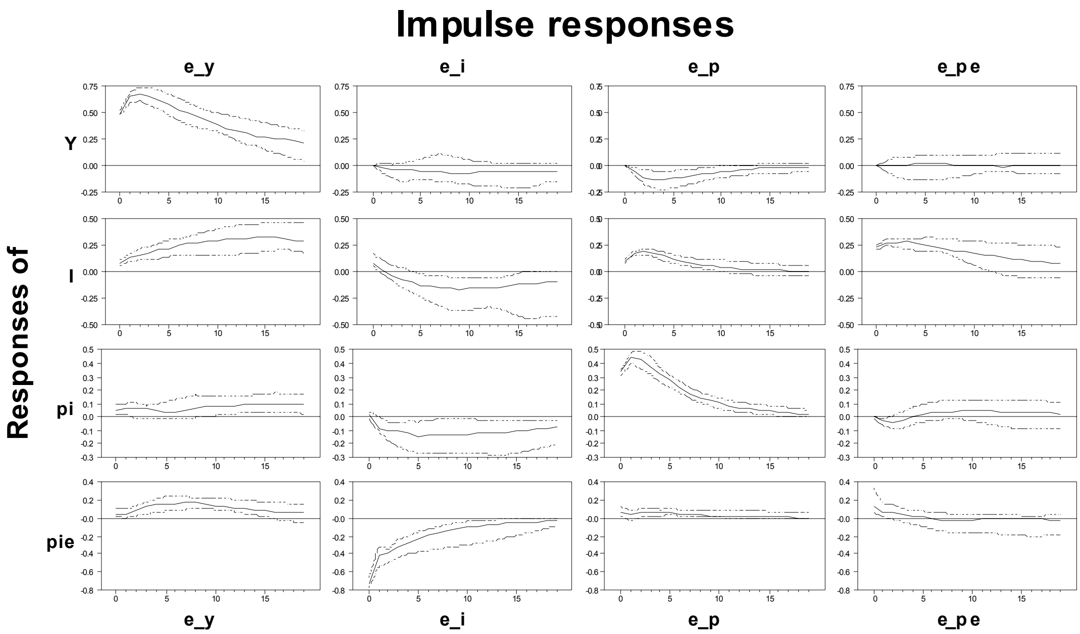

Figure 3: Impulse Responses to Structural Shocks (Japan)

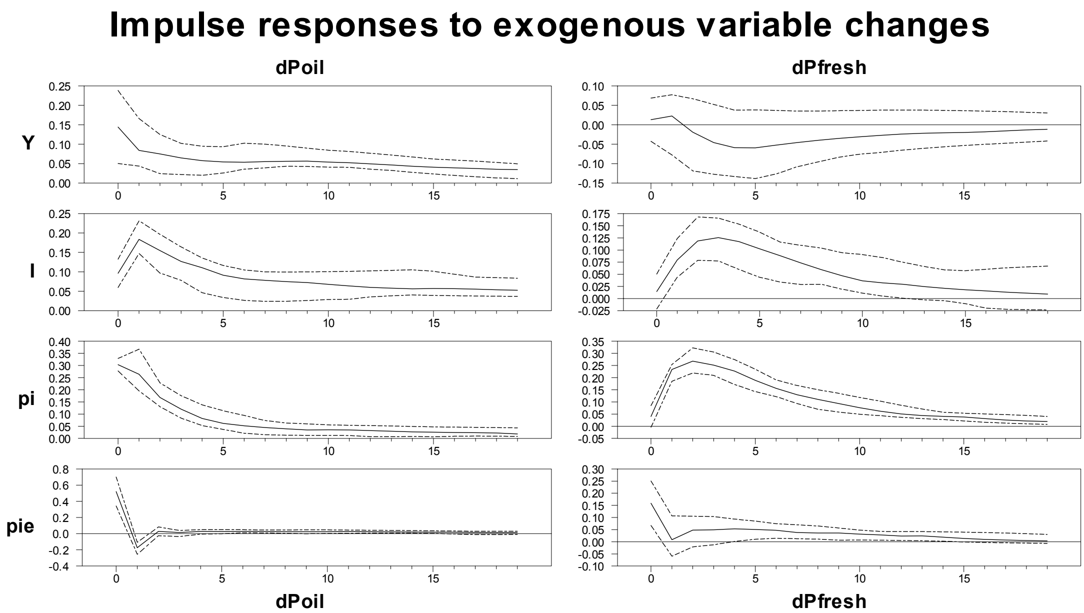

Figure 4: Impulse Responses to Exogenous Variables (Japan)

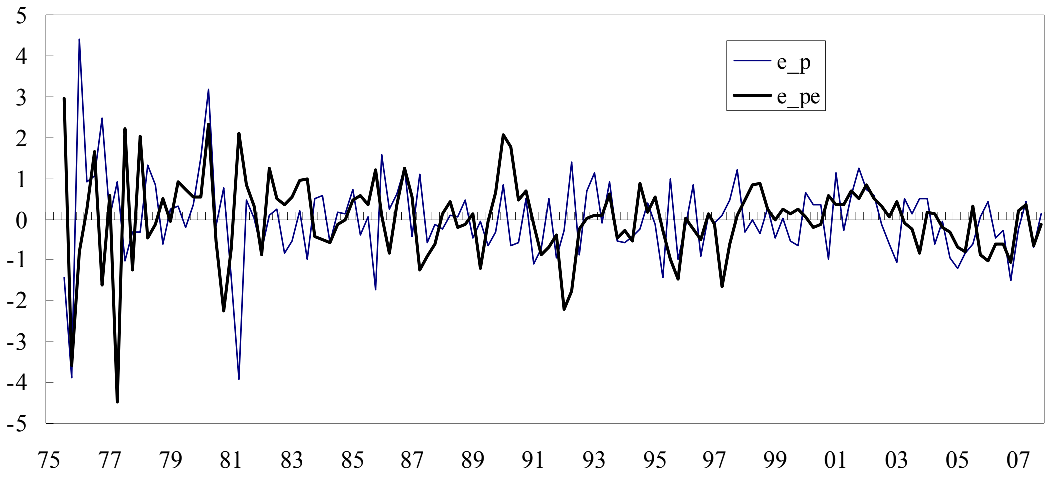

Figure 5: Structural Shocks (Japan)

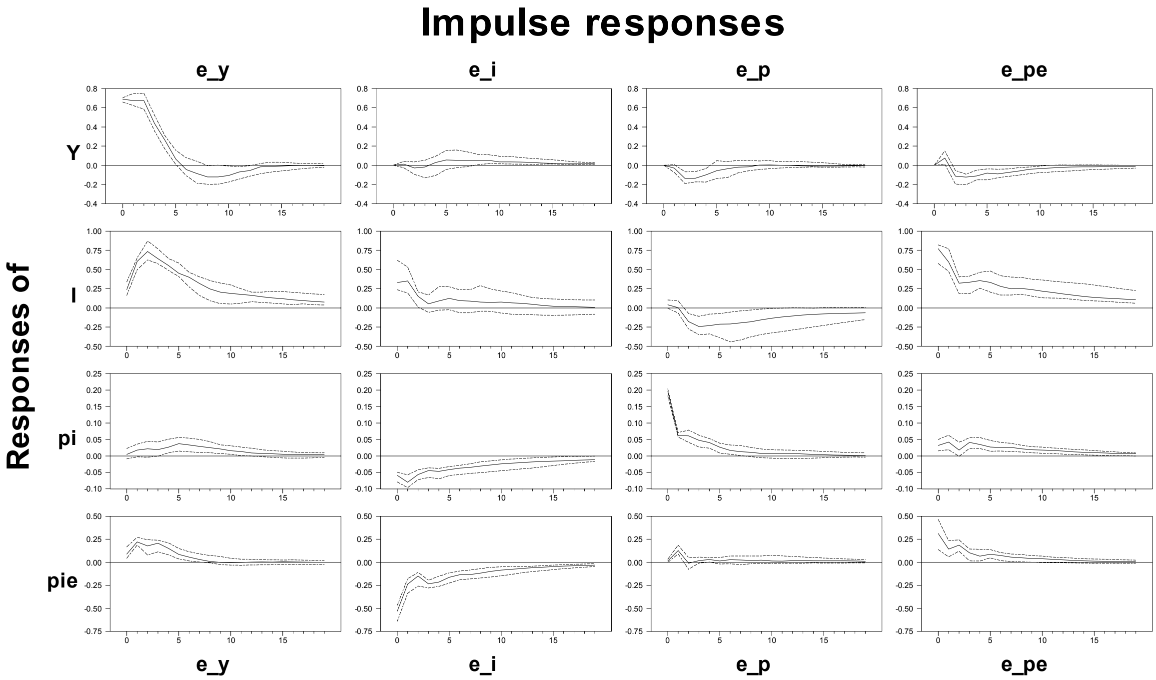

Figure 6: Impulse Responses to Structural Shocks (the United States)

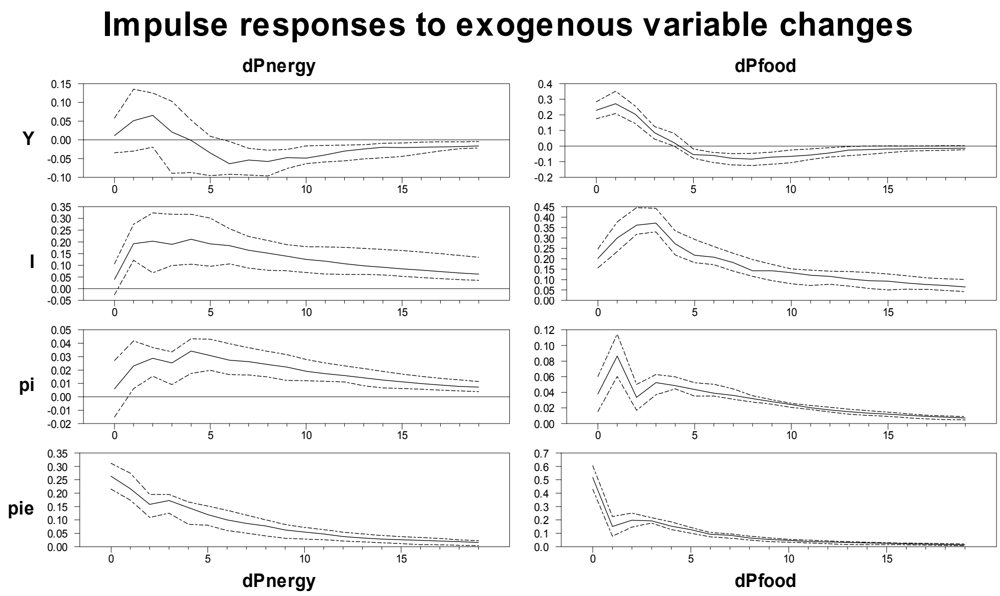

Figure 7: Impulse Responses to Exogenous Variables (the United States)

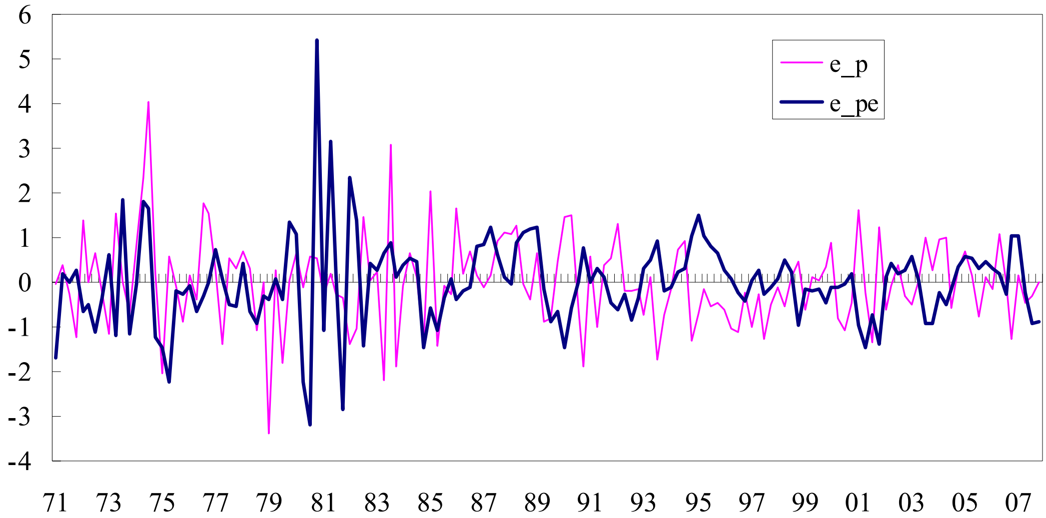

Figure 8: Structural Shocks (the United States)

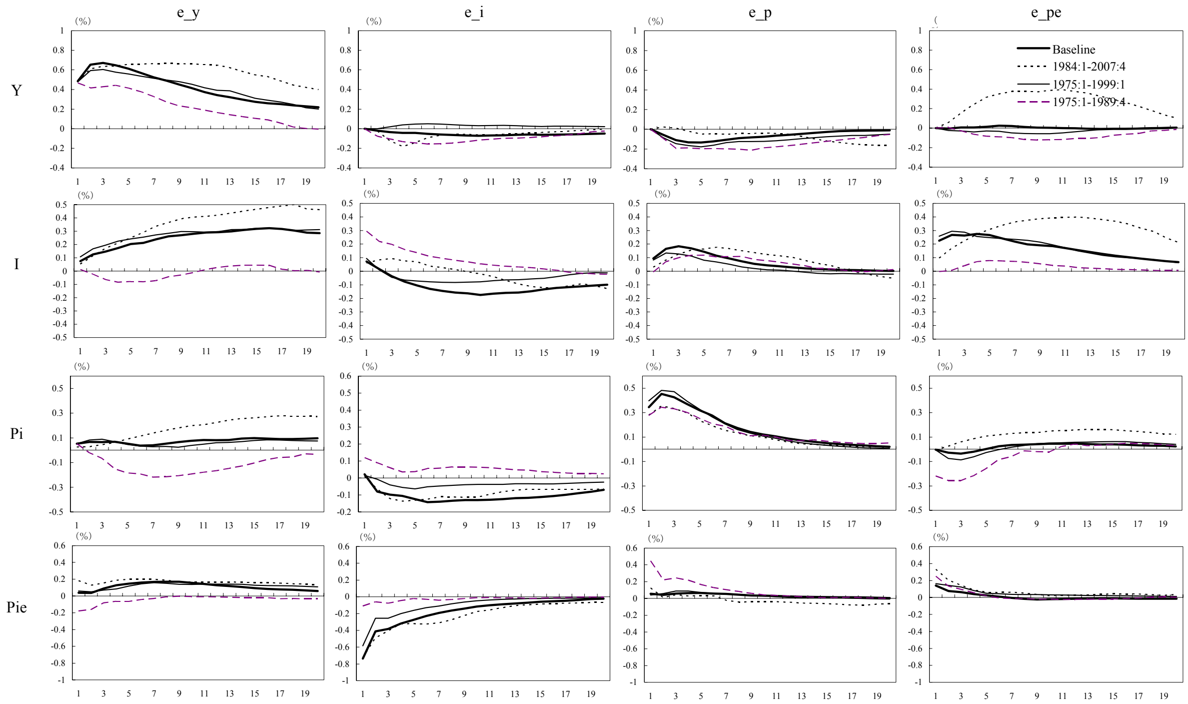

Figure 9: Robustness 1.1: Different Samples (Japan)

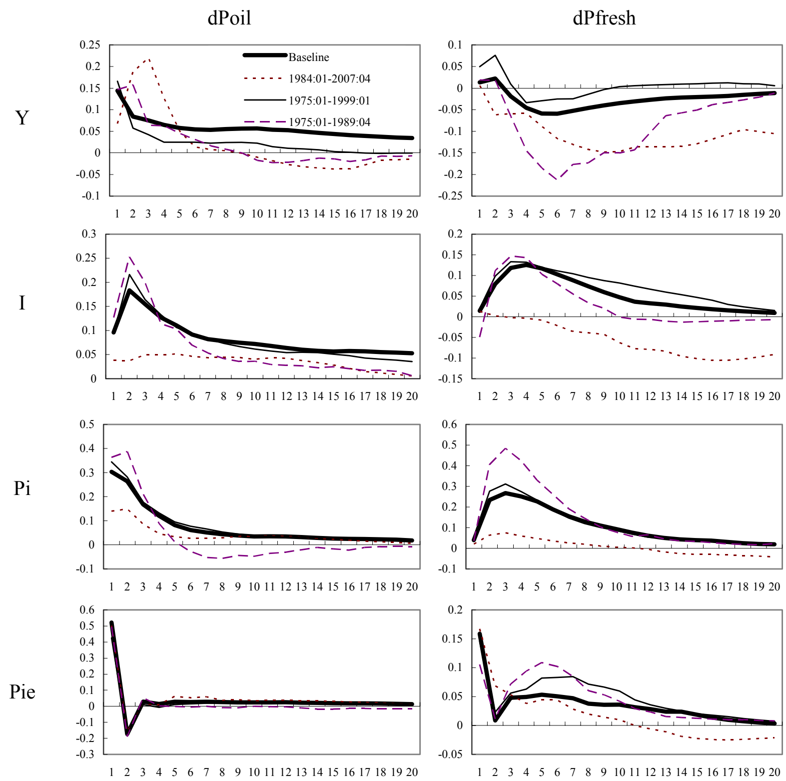

Figure 10 Robustness 1.2: Different Samples (Japan)

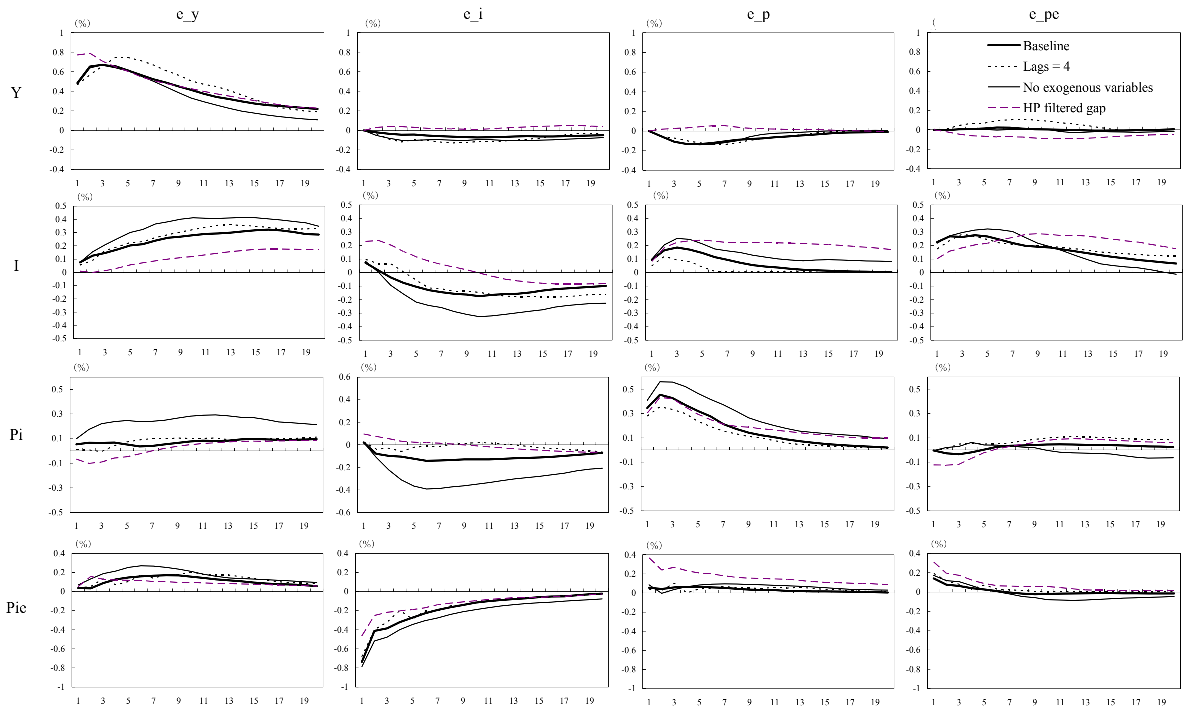

Figure 11: Robustness 2: Miscellaneous Modifications (Japan)

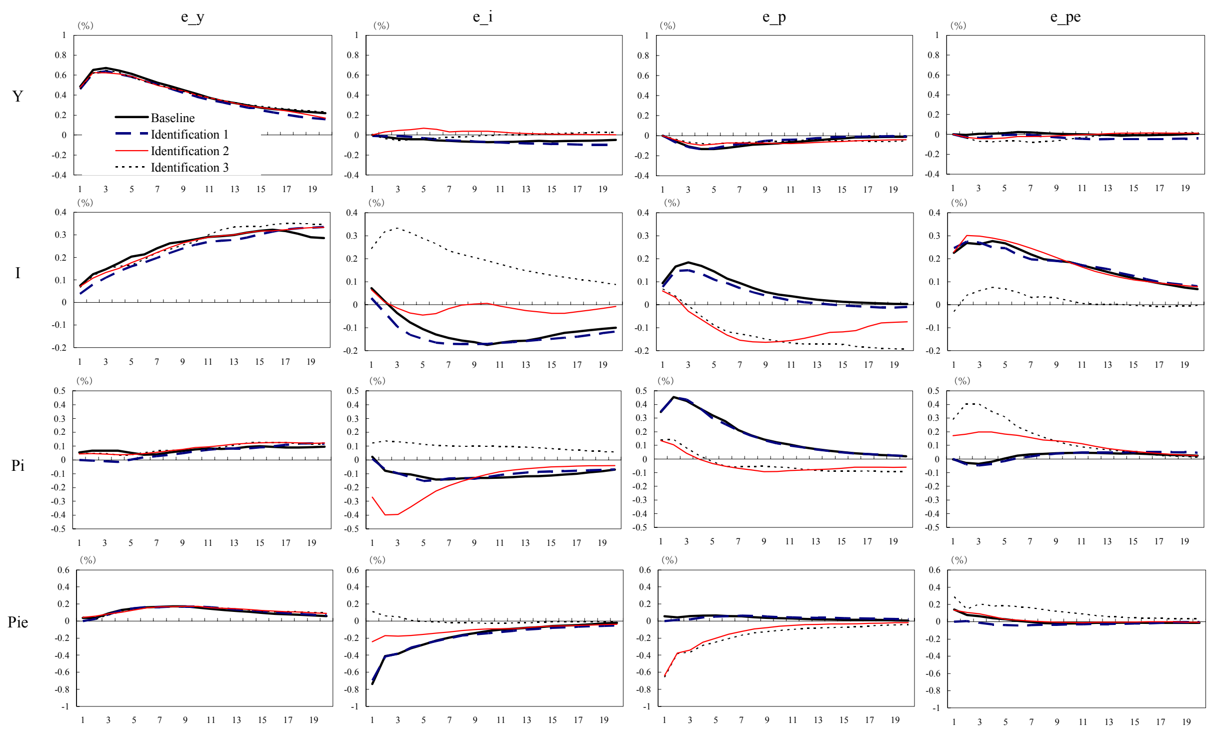

Figure 12: Robustness 3: Other Restrictions (Japan)

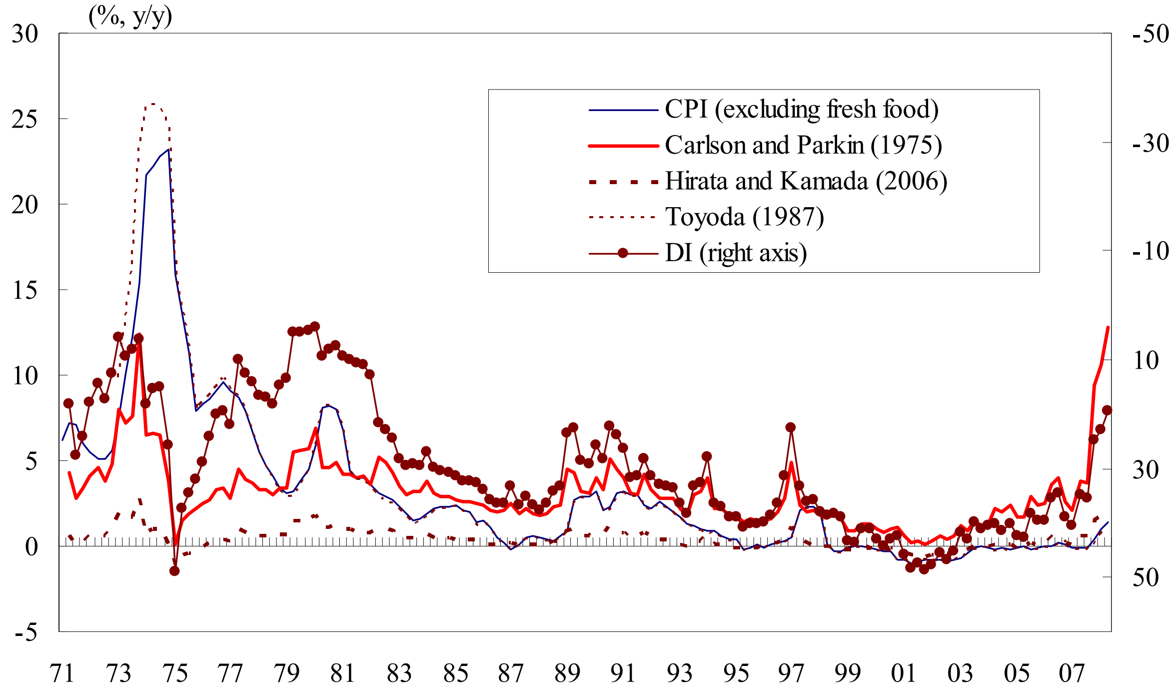

Figure 13: Various Measures of Inflation Expectations (Japan)

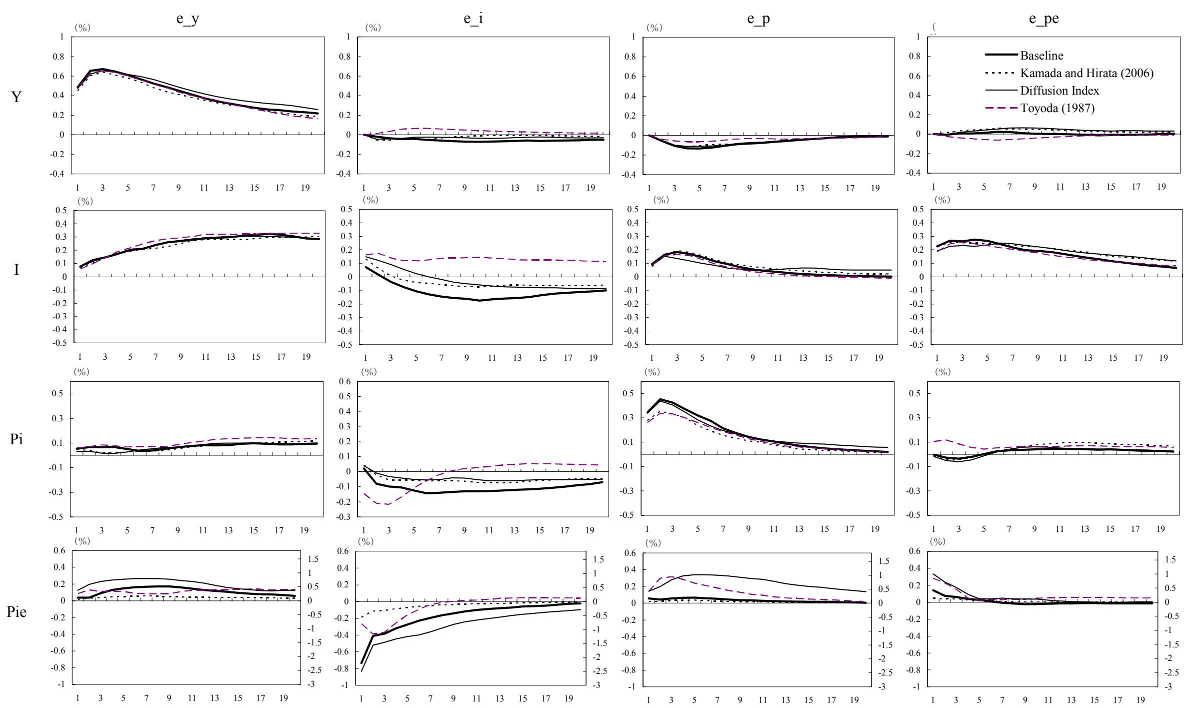

Figure 14: Robustness 4: Various Measures of Inflation Expectations (Japan)

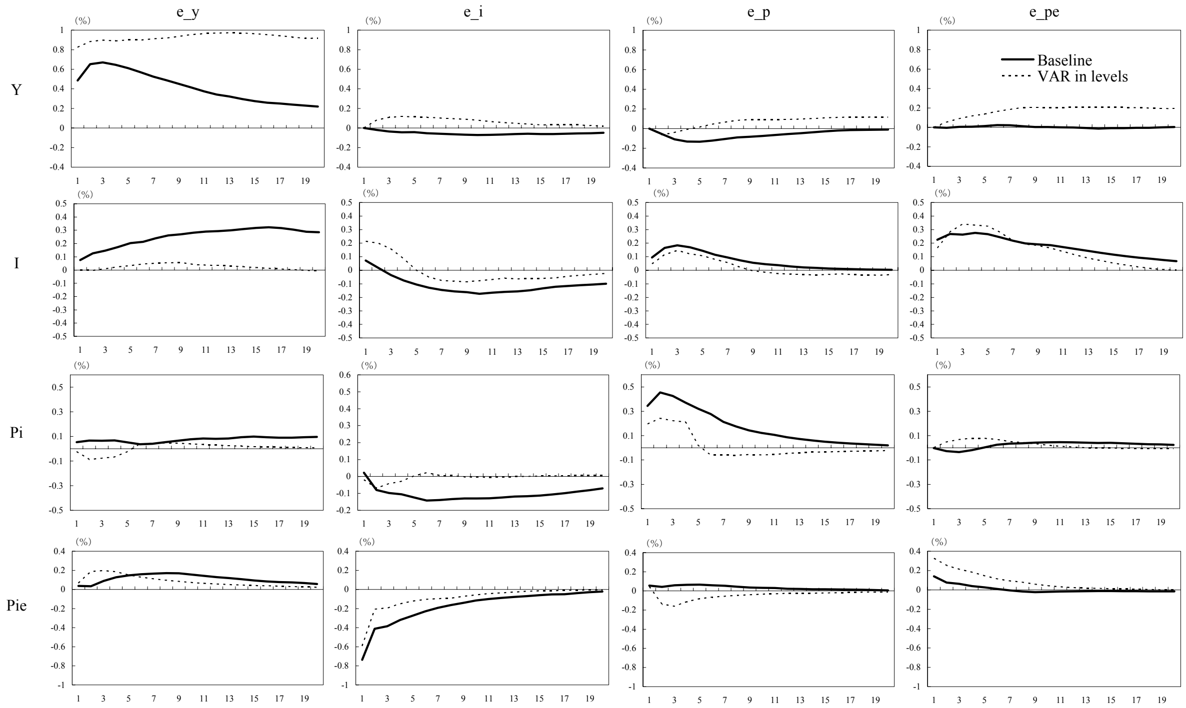

Figure 15: Robustness 5: VAR in Levels (Japan)

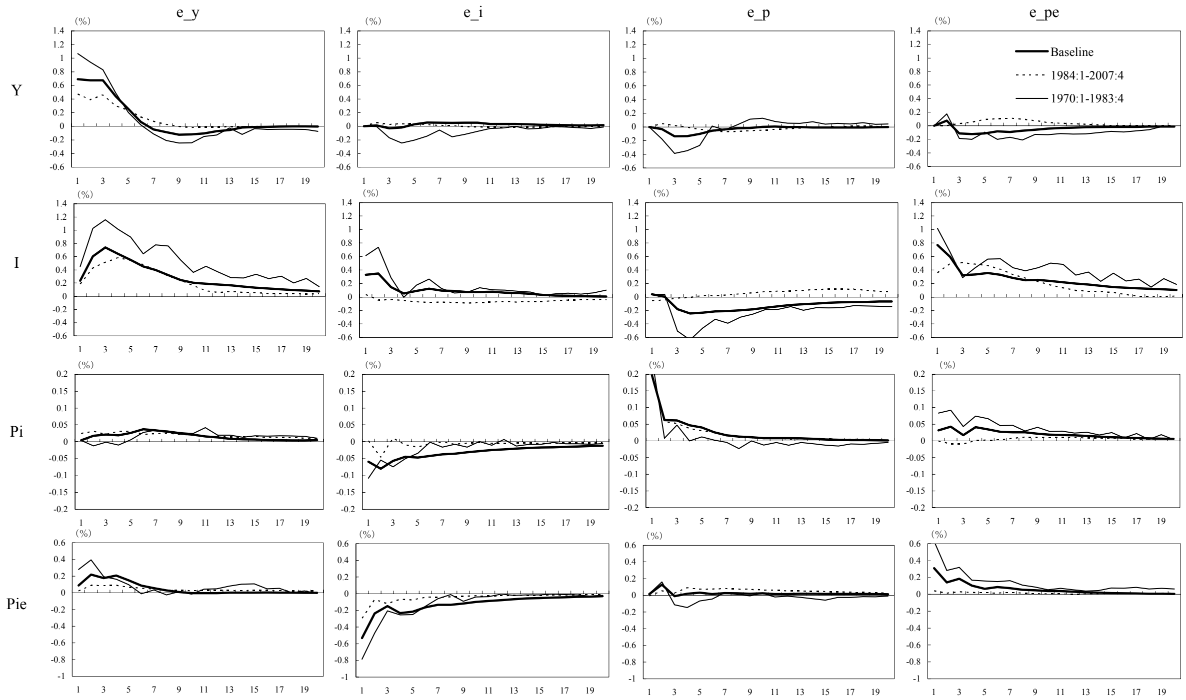

Figure 16: Impulse Responses to Structural Shocks in Different Samples (the United States)

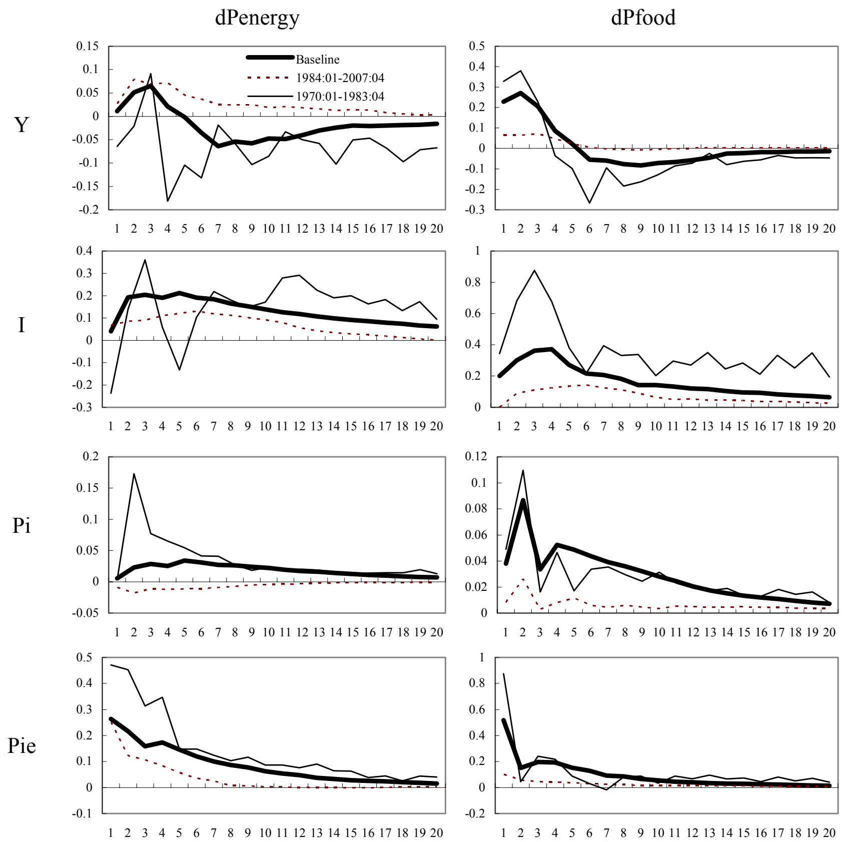

Figure 17: Impulse Responses to Exogenous Variables in Different Samples (the United States)

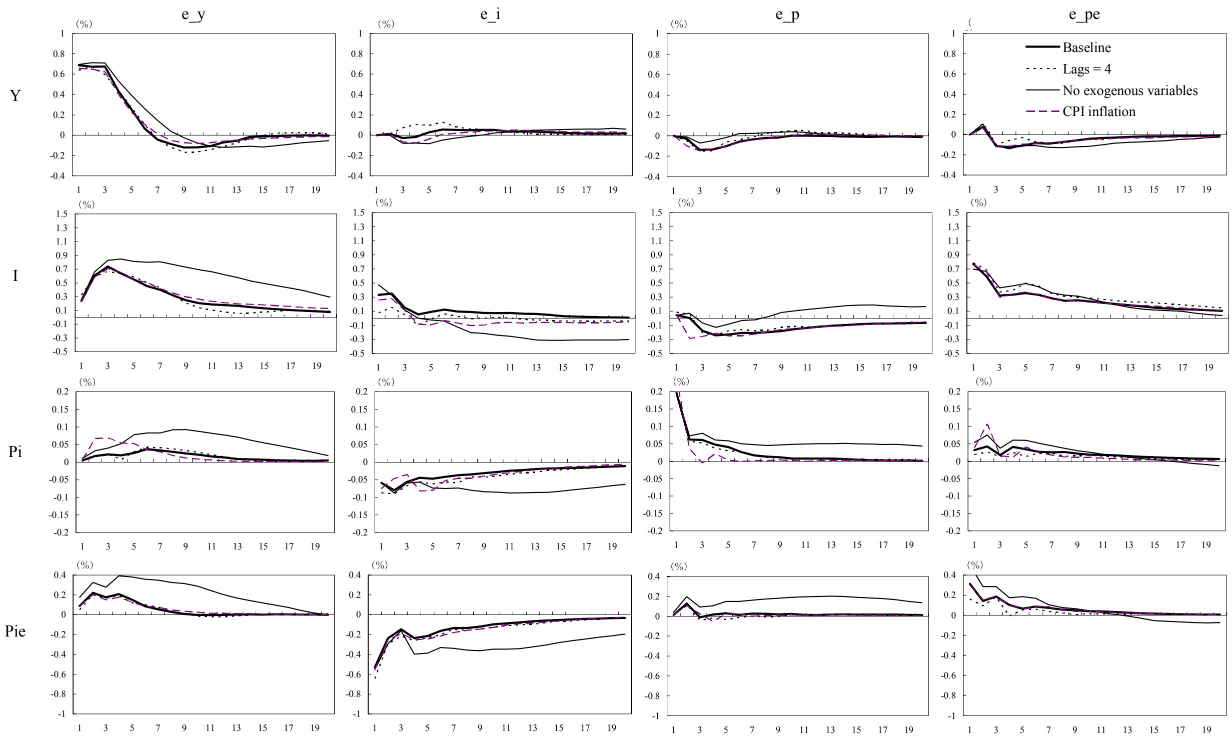

Figure 18: Robustness: Miscellaneous Modifications (the United States)