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Is there any asymmetry in the effect of inflation on relative price variability?

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ABSTRACT

It is widely perceived that relative prices are more dispersed in periods of price decreases than in periods of price increases. We show that the asymmetry results from misspecifying the true, U-shaped, underlying model with a piecewise linear regression model.

1. Introduction

Ever since Parks (1978) first noted that relative prices get more dispersed in periods of price falls than in periods of price rises, the asymmetric effect of inflation on the relative price variability (hereafter, RPV) has been supported by extensive empirical work [e.g. Tommasi, 1993; Reinsdorf, 1994; Jaramillo, 1999; to cite a few]. At a theoretical level, Ball and Mankiw (1994) outline a model of asymmetric price adjustments in which negative inflation shocks trigger a slower adjustment of firms' desired prices and thus yield a larger variation in relative prices than do positive shocks of the same size. Jaramillo (1999) provides further theoretical explanations based on a simple two-sector model with downward price rigidity. The asymmetry also bears a crucial implication for monetary policy as it stipulates different policy responses to different inflation shocks.

By studying disaggregated CPI data for three countries, Canada, Japan, and the U.S., this note makes two major arguments with regard to the asymmetry. First, the ample empirical evidence of asymmetry established in the literature largely results from the misspecification of the regression model. When the usual piecewise linear regression model is applied, we could find evidence of asymmetry, but the degree of asymmetry is not stable over time. Instead, asymmetry dwindles as trend inflation decreases before vanishing completely when trend inflation falls to zero. It is reversed when trend inflation goes below zero as seen in Japan during the period of deflation. We attribute this time-varying behavior of the asymmetry to misspecifying the true underlying model of a nonlinear U-shape with the piecewise linear model. In the trend inflation (deflation), the model misspecification causes a spurious asymmetry by overstating the response of RPV to price decreases (increases), while understating the response to price increases (decreases). Indeed, we find compelling evidence of a U-shaped relationship between inflation and RPV in all countries under study, consistent with the recent findings by Fielding and Mizen (2008) and Choi (2009). Second, in the U-shaped profile, what matters for the response of RPV is not the direction of price changes but the deviation of inflation from a certain threshold level, at which RPV is minimized. The farther away a shock drives inflation from the threshold level in either direction, the more cross-sectionally dispersed relative prices become in a *symmetric* fashion. This threshold inflation level is related to the public's perception of the central bank's inflation target, which is often pinned down by trend inflation. Once the deviation from trend inflation is used as a regressor, our regression results not only show a better fit of the data, but also reveal little evidence of asymmetry. This implies that economic agents respond in a *symmetric* manner to the shocks that drive the actual inflation away from the trend level, lending credence to the view that prices are rigid upwardly as well as downwardly.

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Table 1
Data description.

Country	Number of disaggregates	Data span	Base year	Break point	Data source
Canada	36	1984.M1–2005.M5	1992	1991:M8	Statistics Canada
Japan	47	1984.M1–2006.M7	2000	1998:M12	Statistics Bureau
U.S.	38	1984.M1–2007.M9	2003	1999:M9	BLS

Note: The breakpoints, which divide full sample into two subsamples, are determined by the Bai and Perron (1998) multivariate structural break tests. Base year denotes the period when the weights for CPI items are fixed.

This note is structured as follows. The next section describes the data and presents our empirical results. Section 3 concludes the paper.

2. Empirical results

The data used here are the disaggregated monthly consumer price indices for three industrial countries, Canada, Japan, and the U.S. As summarized in Table 1, the subaggregate price indices are available for 36 categories in Canada, 47 categories for Japan, and 38 categories for the U.S. The sample begins in 1984 which marks the onset of the so-called 'Great Moderation' period when both the volatility and the level of the inflation process have declined significantly in these countries.[1] Inflation is measured by the annualized monthly log-difference of the CPI which is computed from seasonally adjusted price indices using the Census X12-method. Following the convention in the literature, RPV is constructed by the weighted average of the subaggregate inflation series using

$$RPV_t = \sqrt{\sum_{i=1}^{N} \omega_i(\pi_{it}-\overline{\pi}_t)^2}$$

where $\pi_{it}=\ln P_{it}-\ln P_{i,t-1}$, $\overline{\pi}_t = \sum_{i=1}^{N}\omega_i\pi_{it}$, ω_i denotes the fixed expenditure weight of *ith* product that sums to unity, and P_{it} represents the price index of *ith* good at time t.[2]

Empirical evidence on the asymmetric effect of inflation on RPV has been largely drawn from the following piecewise linear regression model. Note that the model embraces both price increases (π_t^+) and the absolute value of price decreases ($|\pi_t^-|$) as separate regressors in order to allow for different rates of response for positive and negative price changes,

$$RPV_t = \alpha_0 + \sum_{h=1}^{r} \alpha_h RPV_{t-h} + \sum_{i=0}^{p} \beta_i \pi_{t-i}^{+} + \sum_{j=0}^{q} \gamma_j |\pi_{t-j}^{-}| + \varepsilon_t. \quad (1)$$

In this specification, β_0 and γ_0 are the key parameters in determining the asymmetric effect on RPV because the degree of asymmetry is captured by the difference between them. To facilitate testing for symmetry, Eq. (1) can be rewritten as

$$\begin{aligned} RPV_t = \alpha_0 &+ \sum_{h=1}^{r} \alpha_h RPV_{t-h} - \theta\pi_t^{+} + \sum_{i=1}^{p} \beta_i \pi_{t-i}^{+} \\ &+ \gamma_0\left(\pi_t^{+} + |\pi_t^{-}|\right) + \sum_{j=1}^{q} \gamma_j |\pi_{t-j}^{-}| + \varepsilon_t. \end{aligned} \quad (2)$$

The null hypothesis of *symmetry* (H_0:$\beta_0=\gamma_0$) can then be tested against the alternative of *asymmetry* (H_A:$\beta_0\neq\gamma_0$) by investigating the statistical significance of the coefficient of asymmetry, $\theta=\gamma_0-\beta_0$.[3] The null hypothesis of symmetry will be rejected in favor of asymmetry if the estimated θ is significantly different from zero. Positive (negative) values of $\hat{\theta}$ indicate a greater (smaller) impact of price decreases on RPV than that of price increases.

The left panel of Table 2 reports the estimation results for the full sample and two subsamples, in which the full sample is split by the break points determined by the Bai and Perron (1998) multivariate structural break tests as presented in Table 1. A couple of features emerge from the table. First, this conventional model specification exhibits strong asymmetries in every country, confirming the general conclusion reached by earlier studies. As presented in the second and third columns of the table, the impact of negative price changes on RPV ($\hat{\gamma}_0$) is far larger than that of positive price changes ($\hat{\beta}_0$), indicating that price decreases are associated with higher RPV than price increases. Consequently, $\hat{\theta}$ reported in column 4 is positive and statistically significant in all cases, with the sole exception of Japan in the post-break period. Second and more important, the degree of asymmetry, measured by $\hat{\theta}$, is not stable but instead varies considerably across subsamples. Notice that $\hat{\theta}$ exhibits a smaller order of magnitude in the post-break period when inflation further stabilized in each country. This decline in the degree of asymmetry is particularly noticeable in Japan, where the asymmetry is even reversed as the sign of $\hat{\theta}$ switches from positive to negative in the post-break period when the Japanese economy fell into deflation. In this vein, the degree of asymmetry is believed to vary systematically with the level of mean inflation, with weaker asymmetry for lower levels of inflation.

To gain further insight into this issue, we conduct a rolling regression analysis, which is a useful tool for capturing the time-varying property of parameters. Fig. 1 displays $\hat{\theta}$ (solid line on the left axis) together with the period average inflation rates (dotted line on the right axis) from a sequence of rolling samples with a window of 8 years. As is clear from the plot, $\hat{\theta}$ shows significant time variation in each country. It moves closely with the period average inflation rate, especially in Canada and Japan where $\hat{\theta}$ has declined over time roughly in tandem with average inflation, reinforcing our prior belief that the degree of asymmetry diminishes with the fall of mean inflation. $\hat{\theta}$ is very close to zero in Japan near the end of sample period, suggesting a lack of asymmetry.

Here we claim that this time variation in the degree of asymmetry results from a misspecification of the regression model in Eqs. (1) and (2). If the true underlying relationship between inflation and RPV is U-shaped around a nonzero inflation rate, specifying it with a piecewise linear model as in Eqs. (1) and (2) would naturally give rise to a spurious asymmetry by overstating the marginal effect of price decreases on RPV, while understating the impact of price increases. The spurious asymmetry would disappear if the relationship is U-shaped around zero inflation, and reverses when the U-shape is around an inflation rate below zero. A graphical illustration of this point is given in Fig. 2.

To substantiate this claim, we present scatterplots of inflation and RPV in Fig. 3 which illustrate two important points. First, the overall relationship between inflation and RPV takes a U-shaped profile around positive threshold inflation rates. This observation accords well with the recent findings by Fielding and Mizen (2008) and Choi (2009).[4] RPV dips with inflation initially before starting to rise back

[1] According to Choi (2009), the relationship between inflation and RPV in most industrial countries underwent an important structural change around the inception of the Great Moderation period.

[2] Weights are fixed throughout the sample period with those of the base year reported in Table 1. The results are qualitatively similar to those based on time-varying weights, which are available from the author upon request. Our results are also robust to the use of core inflation which strips out traditionally volatile prices, such as food and energy related items.

[3] Here we focus on symmetry of the *contemporaneous* effect, but the *cumulative* effect can also be tested for symmetry by setting the null hypothesis of H_0: $\sum_{i=0}^{p}\beta_i=\sum_{j=0}^{q}\gamma_j$ in Eq. (1). We find only a trivial difference between the two approaches mainly due to the dominance of the contemporaneous effect.

[4] The reader is referred to Fielding and Mizen (2008) and Choi (2009) for additional econometric evidence for the U-shaped profile.

Table 2
Regression results.

Country	Regression 1 (inflation level)				Regression 2 (inflation gap)			
	$\hat{\beta}_0$	$\hat{\gamma}_0$	$\hat{\theta}$	$\bar{R}^2$	$\hat{\beta}_0$	$\hat{\gamma}_0$	$\hat{\theta}$	$\bar{R}^2$
Full sample								
CAN	0.14 (13.30)	0.24 (14.77)	0.10‡	0.53	0.17 (14.23)	0.18 (13.67)	0.01	0.61
JPN	0.15 (10.65)	0.18 (8.63)	0.03	0.39	0.16 (10.69)	0.15 (8.09)	−0.01	0.53
US	0.15 (13.43)	0.50 (16.75)	0.35‡	0.61	0.30 (21.24)	0.26 (17.65)	−0.04†	0.75
Before break								
CAN	0.15 (8.66)	0.26 (9.81)	0.12‡	0.53	0.18 (9.37)	0.19 (9.12)	0.01	0.65
JPN	0.14 (8.38)	0.21 (7.67)	0.07‡	0.36	0.16 (8.58)	0.16 (6.88)	0.00	0.52
US	0.10 (7.22)	0.82 (10.34)	0.72‡	0.48	0.22 (11.93)	0.22 (9.55)	0.00	0.70
After break								
CAN	0.12 (8.63)	0.19 (9.69)	0.07‡	0.46	0.15 (8.98)	0.15 (8.76)	−0.01	0.63
JPN	0.20 (5.91)	0.14 (5.11)	−0.07‡	0.39	0.18 (6.01)	0.18 (5.91)	0.00	0.53
US	0.22 (13.89)	0.49 (16.47)	0.28‡	0.79	0.35 (19.03)	0.30 (16.58)	−0.05†	0.85

Note: In Regression 1, inflation level is used for π_t in Eqs. (1) and (2), while inflation gap ($\tilde{\pi}_{t-i} = \pi_t - \frac{1}{T}\sum_{t=1}^{T}\pi_t$) is used in Regression 2. Entries inside the parenthesis represent *t*-values based on the heteroskedasticity-autocorrelation robust standard errors with prewhitening. ‡(†) represents that the null hypothesis can be rejected at 5% (10%) significance level.

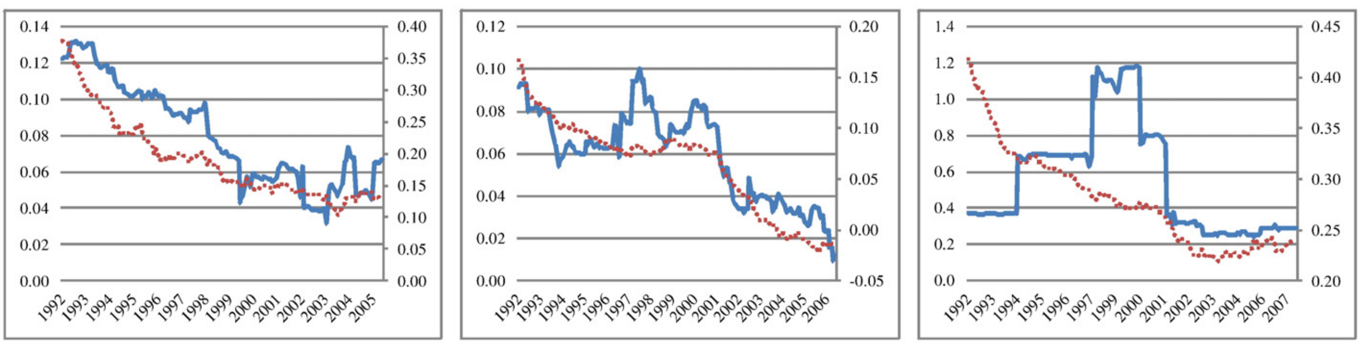

Fig. 1. Degree of asymmetry (solid line) and the period average inflation (dotted line) from rolling regression.

when inflation increases beyond a positive threshold level. Second, the U-shaped profile is not stable but instead moves to the left in the post-break period, judging from the leftward shift of the fitted cubic splines. This leftward shift of the U-shaped profile, stemming primarily from regime changes of inflation or monetary policy, is a contributing factor to the time-varying feature of the asymmetry outlined earlier. To be specific, when the U-shape moves to the left, the responses of RPV to price increases and decreases become more symmetric because $\hat{\gamma}_0$ in Eq. (1) diminishes while $\hat{\beta}_0$ grows and hence $\hat{\theta}$ declines as demonstrated in Fig. 2.

An important implication of the U-shaped profile is the presence of a threshold inflation level at which RPV is minimized, denoted here as π^*. In this case, RPV changes not with the inflation rate per se as widely recognized in the literature, but with the deviation of inflation from π^*. According to Choi et al. (2009), π^* is conceptually related to the target level of inflation perceived by the public, or to the central bank's inflation target, which is often proxied by period average inflation rates.[5] The farther away a shock drives inflation from π^* in either direction, the more cross-sectionally dispersed relative prices become, but in a *symmetric* manner. Given the symmetric feature of the U-shape around π^*, one should expect no evidence of asymmetry if RPV is regressed onto the inflation deviation from π^* instead of zero. This view is supported by the regression results reported in the right panel of Table 2, in which RPV in eq. (2) is now regressed on the deviations of inflation from the period average inflation, or $\tilde{\pi}^+$ and $|\tilde{\pi}^-|$ where $\tilde{\pi}_t = \pi_t - \frac{1}{T}\sum_{t=1}^{T}\pi_t$. Not surprisingly, the results displayed in the right panel of Table 2 are quite different from those on the left panel, with the difference between the two resting on the choice of regressors. In the right panel of Table 2, little evidence of asymmetry can be seen as the difference between $\hat{\gamma}_0$ and $\hat{\beta}_0$ is marginal, and consequently $\hat{\theta}$ is either close to zero or statistically insignificant in most cases. That is, RPV is equally responsive to both upward and downward deviations of inflation from the threshold level. Moreover, the degree of asymmetry is no longer sensitive to the sample period, and also to the level of mean inflation. It is reassuring to note that the new specification fits the data much better as the adjusted-R^2 improves significantly in all cases.

Overall, our findings here suggest that what matters for the response of RPV to inflation is not the direction of price changes but the deviation of inflation from π^*. In light of the symmetric dispersion of relative prices around π^*, price rigidities that give rise to RPV may exist not just downwardly but upwardly as highlighted by some recent studies [e.g. Woodford, 2003].

3. Concluding remarks

Using disaggregated CPI data for three countries, this note shows that the general perception of an asymmetric response of RPV to the direction of price changes results from misspecifying the true model of a U-shape with a piecewise linear regression model. There exists compelling evidence of a U-shaped relationship between inflation and RPV both here and in other studies. A central implication of the U-shaped profile is that RPV changes not with inflation per se but with the deviation of inflation from trend inflation, in a *symmetric* fashion. When this inflation deviation is used as a regressor, regression results reveal little evidence of an asymmetric effect, and the results are robust to different inflation

5 In this context, the deviation of inflation from π^* is similar in spirit to the *inflation gap* described by Cogley et al. (2010) and Sbordone (2007).

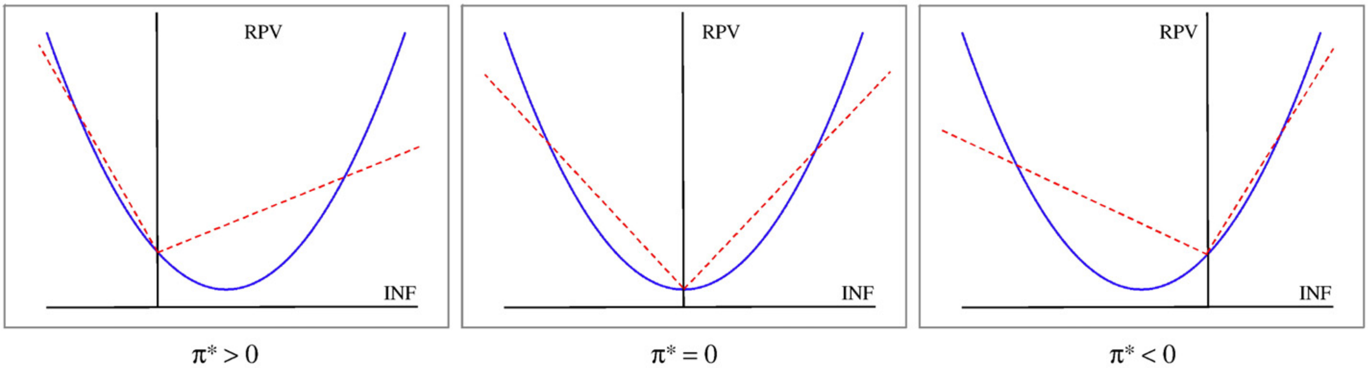

Fig. 2. Misspecification of U-shaped underlying models by a piecewise linear model.

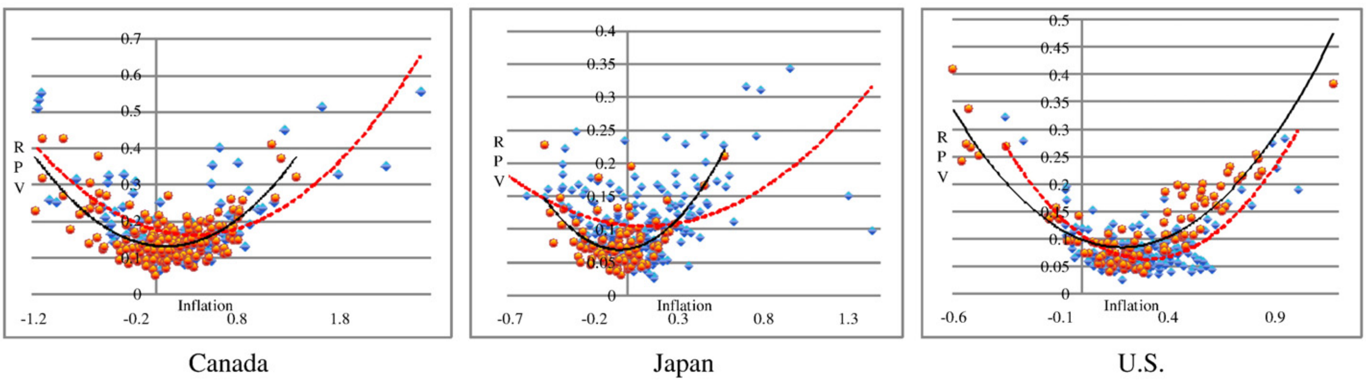

Fig. 3. Inflation and RPV before (◇ and dotted trend line) and after (• and solid trend line) breakpoints.

regimes. Therefore, it seems more appropriate to characterize the response of RPV to inflation as symmetric, as long as we focus on price shocks that drive inflation away from trend inflation.

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