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Abstract

This study examines whether skewness of cross sectional distribution of relative price shocks has asymmetric impact on aggregate inflation. The empirical evidence from various countries suggests that the positively skewed shocks have different impact from that of negatively skewed shocks on aggregate inflation. Consistent with the predictions of menu cost models, the empirical results indicate that this asymmetry in the impact of relative price shocks mainly depends on the nature of trend that inflation exhibits for a given period. The crucial inference that emerges from the empirical findings is that the traditional approach of using a linear regression model, to examine the relationship between inflation and skewness during the period with trend inflation, is not appropriate as it may result in misspecification and misleading conclusions.

Keywords: *Inflation; distribution of relative price shocks; menu costs; asymmetry*
JEL Codes: *E30; E31; E52*

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INTRODUCTION

The rigidity in price adjustment has assumed a central importance in new Keynesian theoretical models. One crucial implication of staggered price setting in these models is the positive association between aggregate inflation and skewness of the cross sectional distribution of relative price shocks.[1] A formal theoretical framework which explains this relationship is provided by Ball and Mankiw (1994, 1995). Ball and Mankiw (1995) demonstrate that in presence of menu cost it is optimal for firms to respond only to shocks that are large in size but not to small ones. Hence, under the assumption of menu costs, firms' prefer to choose inaction for a range of shocks that are smaller in size. One crucial implication of such price adjustment is that the short run fluctuations in aggregate inflation largely depend on the distribution of aggregate shocks; positively skewed shocks lead to rise in aggregate inflation whereas negatively skewed shocks result in fall in aggregate inflation. Following Ball and Mankiw (1994, 1995), a large number of empirical studies have provided evidence in favor of positive association between inflation and skewness of cross sectional distribution of relative price changes (see e.g., Ball and Mankiw (1995); Amano and Macklem (1997); Dopke and Pierdzioch (2000); Aucremanne *et. al.* (2002); Caraballo and Usabiaga (2004); and Assarsson (2004)). More recently, Rather *et. al.*, (2015); Tripathi and Goyal (2013); Catik *et. al.* (2010) and Caraballo *et. al.*, (2009) have empirically examined the reliability of skewness as an alternative measure of supply shock in various countries. Extending this strand of literature, Pou and Debus (2008), using traditional linear regression model, found that the relationship between inflation and the skewness varies across countries and depends mainly on the inflationary history of the country. He argued that this relationship is very evident during the periods of low inflation whereas it ceases to exist during the periods characterized with positive trend inflation. Based on these

[1] Note that in Classical framework, skewness of relative price shocks is perceived to have no impact on average inflation (Friedman, 1975).

findings, the study raises doubts on the validity and predictions of menu-cost models particularly during the periods characterized with trend inflation. Also, number of other studies, such as Lourenco and Gruen (1995), Caraballo and Usabiaga (2004) and Raftai (2006), while examining the relation between inflation and the skewness in different inflationary regimes, suspected the strength of this relationship during high inflationary periods.

In this paper, I argue that such theoretically inconsistent results might arise due the use of traditional linear regression model during the periods characterized with trend inflation. It is important to note that in presence of trend inflation, the price adjustment of firms in the menu cost models is not symmetric in upward and downward directions. In particular, Ball and Mankiw (1994) have demonstrated that in presence of *positive* trend in inflation, it is optimal for the firms to adjust prices only in response to shocks that raise firms' desired prices whereas choose inaction in response to shocks that reduce their desired prices. This is due the reason that the positive (negative) trend in inflation causes firms' relative prices to decline automatically between price adjustments over time and therefore does not necessitate downward (upward) adjustments. In this context, Ball and Mankiw (1995) have shown that the positive (negative) trend in inflation will result in inaction zone which is asymmetric around zero. That is, in presence of *positive* trend in inflation, a positive shock will trigger quicker upward adjustment whereas a negative shock of same size will cause no or delayed adjustment in downward direction, and reverse will be the case in presence of *negative* trend in inflation.

Thus in presence of *positive* trend inflation, the positively skewed shocks are expected to push the aggregate inflation to a higher level as the price adjustments in upward direction are realized much quickly and to the full extent. Whereas under the same setting, the negatively skewed shocks will have small or no impact on aggregate inflation as

most of the desired price adjustments in downward direction (even though large in size) occur either in a very sluggish manner or do not occur at all. In contrary, in presence of *negative* trend in inflation, the down price adjustments are effected more quickly than upward adjustments. In such a situation, negatively skewed shocks are expected to affect aggregate inflation more strongly than the positively skewed shocks. Note that such asymmetric impact of skewness in presence of trend inflation is likely to exist even if the shocks to desired prices are symmetrically distributed.

Based on this premise, the skewness of cross sectional distribution of relative price shocks is expected to have an asymmetric impact on aggregate inflation depending on the sign (and magnitude) of trend in inflation. In particular, in presence of positive trend inflation, positively skewed shocks will lead to higher aggregate inflation and negatively skewed shocks will not reduce inflation. Whereas, when inflation exhibits negative trend, negatively skewed shocks are likely to reduce the aggregate inflation whereas positively skewed shocks will have no or less impact on aggregate inflation. Hence, during a period with trend inflation, the traditional approach of using the conventional linear regression model to examine the impact of relative price shock on inflation is not appropriate.

In this context, this study examines whether the positively skewed relative prices shocks have different impact from that of negatively skewed shocks on aggregate inflation during the periods with positive/negative trend inflation. To this end, I first identify various inflationary episodes characterized with positive trend inflation and the episodes with negative trend inflation, across different counters. Next, unlike traditional literature, I use piecewise linear regression model by incorporating positive and negative skewness separately to examine the asymmetric impact of skewness on inflation. The empirical evidence from cross country analysis indicates that the shocks that are positively

skewed do not have the same impact as that of negatively skewed shocks on aggregate inflation. The empirical findings corroborate the predictions of menu cost models of Ball and Mankiw (1994, 1995). The results suggest the use of conventional regression model to examine this relationship in presence of trend inflation will result in misspecification and thereby, misleading inferences. The rest of the paper is organized as follow: in section 2 econometric methodology is discussed, section 3 provides empirical results and section 4 draws the conclusion.

METHODOLOGY

In empirical examination of the relationship between inflation and skewness of the distribution of relative price shocks, the common practice in litrature is to use a measure of skewness constructed from the distribution of actual/observed price changes as a proxy for the skewness of the distribution of desired price changes due to unavailability of data on desired price changes. Following Pou and Debus (2009), the skewness of the cross sectional distribution of relative price changes (S_t) is measured as follows:

$$S_t = \left[\sum_{i=1}^{N} \omega_i \left(\pi_{it} - \pi_t \right)^3 \right] \times \sigma_t^{-3/2}.$$

where π_{it} is the change in price of i^{th} commodity in period t and π_t is the aggregate/average inflation in period t. ω_i represents the weight of i^{th} commodity.

In traditional empirical literature, the following conventional linear regression model is widely used to estimate this relationship.

$$\pi_t = \alpha + \sum \gamma_k \pi_{t-k} + \beta S_t + \varepsilon_t \qquad (1)$$

where π is the aggregate inflation and γ is the coefficient associated with the lagged inflation which captures the persistence. Also, β is coefficient associated with skewness which captures its impact on aggregate inflation. ε_t is the disturbance term with zero mean and constant variance. It is important to note that the above specification is not appropriate during the periods with a trend inflation as it does not take into account the asymmetry in the effects of skewness. Unlike conventional linear model, we employ a piecewise regression model to capture the asymmetry in the impact of skewness on aggregate inflation:

$$\pi_t = \alpha + \sum_{h=0}^{r} \gamma_h \pi_{t-h} + \sum_{i=0}^{p} \beta_i S_{t-p}^{+} + \sum_{j=0}^{q} \rho_j S_{t-j}^{-} + \varepsilon_t \qquad (2)$$

where β_i and ρ_j capture the influence of positive skewness $\left(S_t^{+}\right)$ and negative skewness $\left(S_t^{-}\right)$, respectively. [2] Here, if $|\beta_0|$ turns out to be significantly greater than (ρ_0) then positive skewness have stronger impact than the negative skewness and vice-versa. Theoretically, we expect $|\beta_0| \succ |\rho_0|$ during a period with *positive* trend in inflation and $|\beta_0| \prec |\rho_0|$ during the period characterized with *negative* trend inflation. To test the statistical significance of this asymmetry, the above equation

$$\pi_t = \alpha + \sum_{h=1}^{r} \gamma_k \pi_{t-k} - \theta(S_t^{+}) + \sum_{i=1}^{p} \beta_i S_{t-i}^{+} + \rho_0 (S_t^{+} + |S_t^{-}|) + \sum_{j=1}^{q} \rho_j |S_{t-j}^{-}| + \varepsilon_t \qquad (3)$$

is modified as:

[2] Here, I focus only on the symmetry of contemporaneous effect.

where the null hypothesis of symmetry is rejected in favor of asymmetry, if θ is significantly different from zero. The positive (negative) value of θ indicate larger (smaller) impact of negative skewness than positive skewness on inflation.

DATA AND EMPIRICAL RESULTS

To carry out the empirical analysis, we used monthly data on the component price indices of PPI for US, Japan, Spain, India and the CPI for UK. First, we identify whether the inflation series of a particular country exhibits positive and (or) negative trend by visualizing the plots of inflation series of the respective countries. The plots of US inflation rate indicate that there is a secular negative trend in aggregate inflation during the sample period from January-2004 to January-2014. Likewise, the inflation rate of Japan for sample period from January-1976 to December-2011 exhibits a negative trend similar to what is observed for the US. In case of UK, inflation seems to have a negative trend during January-1996 to December-2001 and a positive trend for the period from January-2002 to March-2014. Similarly, India experienced an upward trend in inflation for the period from April-1993 to December-1998 and a downward trend during the period January-1999 to December-2008. The empirical analysis for each country was carried out during these respective inflationary episodes.

Before proceeding to empirical analysis, we examine the time series properties of all the variables under consideration. To this end, we used Augmented Dicky-Fuller (ADF) and Phillip-Perron (PP) unit root tests.[3] The results from ADF test, presented in Table 1, indicate that the inflation series of all the countries is trend stationary as the null of unit root is rejected when a given series is considered with a trend.[4] Also, the

[3] Same results were obtained from PP test and are not presented here.
[4] The trend variable in Dicky-Fuller equations of all the inflation series was found to statistically significant.

results suggest that the null hypothesis that a given skewness measure has unit root is rejected at conventional level in case of all the countries. This confirms that all the skewness measures are stationary and hence follow the $I(0)$ process.

Table 1: Unit Root Tests

Variables/ Country	Spain	US	Japan	India (regime1)	India (regime2	UK (regime1)	UK (regime2)
Inflation	-1.35	-2.42	-1.90	-0.68	-0.14	-2.36	-2.19
	(0.60)	(0.13)	(0.33)	(0.84)	(0.90)	(0.15)	(0.21)
Inflation with	-3.25	-3.66	-3.30	-3.70	-4.10	-3.52	-3.03
trend	(0.05)	(0.02)	(0.05)	(0.05)	(0.00)	(0.05)	(0.05)
Skewness	-3.06	-4.16	-5.21	-1.98	-3.88	-2.11	-3.09
	(0.03)	(0.01)	(0.00)	(0.05)	(0.00)	(0.05)	(0.03)

Note: p-values are represented in parentheses.

Next, we estimate equation (2) and (3) using simple Ordinary Least Squares technique during the various inflation regimes of the respective countries. In both the equations a trend variable was included in case of all the countries. The results are presented in Table 2. The results, given in the first row of the Table, indicate that the inflation rate for Spain during the sample period exhibits a negative trend as the coefficient associated with trend turns out be significantly different from zero. The results from piecewise linear regression model suggests that the coefficient associated with negative and positive skewness are significantly different from zero, as is indicated by the associated t-statistic. Also, the coefficient associated with positive-skewness is smaller than the coefficient associated with negative-skewness and the value of θ obtained from Equation 3 is also found to be significantly different from zero with positive sign. These result imply that the negatively skewed shocks have significant impact on aggregate inflation whereas positively shocks do not have any influence on inflation. In other words, in presence of negative trend inflation, the negatively skewed shocks tend to reduce the inflation and the positively skewed shocks do not build any inflation pressure. These result are consistent with the predictions of menu cost models of Ball and Mankiw (1994, 1995). In contrary to Pou

and Debus (2008), the empirical results suggest that the relationship between inflation and the skewness continues to hold even during the periods of high inflation when such asymmetry in the impact of skewness is taken into account. These empirical findings imply that the use of traditional approach of using a conventional linear regression model, as used Pou and Debus (2008), is not appropriate approach as it may lead to misspecification and hence, misleading inferences.

Table 2: Empirical results for Spain, US and Japan

Country/Variables	Trend inflation	C	β	ρ	θ
Spain	-0.020	2.49	0.26	**-0.47**	**0.21**
	(-3.18)	(4.57)	(2.51)	**(-3.10)**	**(8.22)**
US	-0.052	7.27	0.11	**-1.14**	-
	(-8.60)	(11.5)	(0.54)	**(-5.60)**	-
Japan	-0.028	9.20	0.06	**-0.82**	-
	(-21.1)	(25.3)	(0.25)	**(-2.20)**	-

Note: t-Values are represented in parentheses. β and ρ are obtained from Equation 2, and θ is obtained from Equation 3.

To complement these findings, we also provided evidence from US, UK, Japan and India. The results for US are given in the second row of the Table 2. The results indicate that the US inflation during the sample period exhibits negative trend. Similar, to the findings from Spain, the coefficient associated with negative skewness is found to be significantly different from zero, whereas the coefficient associated with positive skewness is found to be insignificant; thereby implying that the positively skewed shocks do not have significant impact on aggregate inflation.[5] Similar are the result for Japan, as given in the third row of the Table.

More convincing evidence is found from UK and India as both of the countries exhibit both a positive trend in inflation for a certain period and a negative trend in inflation during the other period of time. The

[5] The equation (3) was not estimated for US as the coefficient associated with positive skewness turned out to be statistically insignificant.

result are presented in Table 3. In case of UK, during the sample period where inflation exhibits negative trend (regime 1), the results suggest that the coefficient associated with negative skewness is significantly different from zero whereas the coefficient with positive skewness turn out to be statistically insignificant. However, for the period (regime 2) during which inflation exhibits positive trend, the results indicate that the coefficient associated with positive skewness is significantly different from zero whereas coefficient associated with negative skewness is not; suggesting that that positively-skewed shocks have significant impact on aggregate inflation during the periods with positive trend inflation. Similarly, for India, the results for the period with negative trend in inflation (regime 1) indicate the negative skewness significantly affects aggregate inflation and positive skewness is found to have no impact. Whereas during the period with positive trend inflation (regime 2), the positive skewness seem to have significant impact on aggregate inflation.

Table 3. Empirical Results for UK and India

Country/Variables	**Trend Inflation**	**C**	β	ρ
India (regime 1)	-0.151	10.8	0.02	**-1.46**
	(-9.62)	(16.9)	(0.12)	**(-2.00**)
India (regime 2)	0.045	-1.10	**0.67**	-0.11
	(12.3)	(-3.76)	**(3.92)**	(-0.47)
UK (regime 1)	-0.010	1.39	-0.11	-**0.16**
	(-3.04)	(8.46)	(-1.71)	**(-3.70)**
UK (regime 2)	0.032	-1.76	**0.37**	0.04
	(13.6)	(-6.26)	**(3.37)**	(0.65)

Note: t-Values are represented in parentheses. β and ρ are obtained from Equation 2.

These results from both UK and India suggest that during a period with negative trend inflation, the negatively-skewed shocks results in lower rate of inflation whereas the positively-skewed shocks do not lead to higher rate of inflation. In contrary to this, during the period with positive trend inflation, the positively-skewed shocks result in higher

inflation but the negative-skewed shocks do not cause the rate of inflation to fall.

Overall, the empirical evidence confirms that the impact of relative price shocks on aggregate inflation mainly depends on the nature of trend inflation. That is during the period of negative trend in inflation, the negatively skewed shocks affect aggregate inflation more strongly than do the positively skewed shocks. In contrary to this, during the period of positive trend inflation, the positively skewed shocks have more significant impact on the aggregate inflation and negative skewness have less or no influence on aggregate inflation. It is important to note that in presence of these asymmetries, the use of conventional linear regression model to examine the relationship between inflation and skewness of relative price shocks will lead to the misspecification and misleading inferences.

CONCLUSION

This study examines whether skewness of the cross sectional distribution of relative price shocks have asymmetric impact on aggregate inflation during the periods characterized with trend inflation, as predicted by Ball and Makiw (1994, 1995). The empirical evidence from various countries suggests that the positively skewed shocks have different impact from that of negatively skewed shocks on aggregate inflation. Consistent with the predictions of menu cost models, the empirical results indicate that this asymmetry in the impact of relative price shocks mainly depends on the nature of trend that inflation exhibits for a given period. More specifically, during the period of negative trend inflation, the negatively skewed shocks affects aggregate inflation more strongly than do the positively skewed. Whereas, during the period of positive trend inflation, positively skewed shocks have significant impact on the aggregate inflation and whereas negatively skewed shocks seem to have less or no influence on aggregate inflation. The crucial inference that emerges from

the empirical evidence is that the traditional approach of using a linear regression model in presence of such asymmetry is not appropriate as it may result in misspecification and misleading inferences.

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