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ASYMMETRIC PRICE ADJUSTMENT - EVIDENCE FOR INDIA

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Asymmetric Price Adjustment - Evidence For India

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Abstract

We construct an error correction mechanism to examine whether firms' price adjustment is asymmetric as anticipated by Ball and Mankiw (1994). We have used monthly time series data on prices of 418 commodities, which constitute 97 percent of commodity price basket used in the construction of wholesale price index in India. The empirical evidence indicates that the price adjustment of most of the firms exhibits strong asymmetry; shocks that increases firms' desired prices causes quicker and larger rise in prices whereas shocks that lower desired prices causes smaller or no fall in prices. Also, we identify a threshold value for each firm below which it does not allow its relative price to fall. These evidences imply that larger relative price variability can trigger inflation even in the absence of demand shocks. Moreover, the distribution of output is likely to be negatively skewed even if the demand shocks are symmetric.

Keywords: *Menu cost, asymmetric price adjustment, relative price, error correction*

JEL Codes: *C32, E31, E52*

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INTRODUCTION

Number of empirical studies in literature have provided evidence in favour of proposition that negative monetary shocks effect output more strongly than the positive shocks of the same magnitude (Cover, 1992; De Long and Summers, 1988; Rhee and Rich, 1995; and Karras and Stokes, 1999).[1] Theoretically, in traditional models this asymmetric impact of monetary shocks is explained by models based on the assumption of rigidity in the price and/or wage levels that generate convex aggregate supply curve. More recently, Ball and Romer (1989, 1990) and Ball and Mankiw (1994, 1995) have provided micro foundations for such nominal rigidities while assuming the existence of menu costs and trend in inflation. Ball and Mankiw (1995) demonstrate that in presence of menu costs, it is optimal for firms to adjust prices only in response to large shocks but not to small ones. Also, Ball and Mankiw (1994) have shown that in presence of positive trend in inflation it is optimal for firms to respond more quickly to positive shocks than negative shocks of same size. Their argument is based on the rationale that due to the positive trend inflation the relative price of a particular firm fall continuously over time thereby making downward (upward) price adjustments, in response to negative (positive) shocks to desired prices, less (more) likely to occur as it has to incur menu costs. Therefore, under these circumstances, the upward adjustments in prices are expected to occur more quickly than the downward adjustments. Hence, in both the theoretical models, the asymmetry in the output effects of demand shocks basically originates from asymmetries in the price adjustment of firms.

On empirical front, however, most of the empirical studies have mainly focused on asymmetric output effects of aggregate shocks and

[1] On the other hand, another stream of literature such as Garcia and Schaller (2002), Dolado and Maria-Dolores (2002), Peersman and Smets (2001) and Kaufmann (2002) assessed this asymmetry in the business cycle phases and found that monetary policy actions have stronger effects on output during recession.

only a few studies have examined the asymmetry in price adjustment of firms.[2] The first attempt in this direction was made by Buckle (2000). Using the survey data he found the evidence in favor of the proposition that firms adjust prices upwards more quickly in response rise in costs whereas the down word adjustment in response to reduction in costs occurs very slowly. Another attempt in this direction was made by Senda (2001). Although, he found that the effects of monetary shocks on output are asymmetric, however, he could not found any asymmetry in the effects of monetary shocks on the aggregate price. He attributed these inconsistent results to the lack of appropriate price equation.

We argue that such contradictory results found by Senda (2001) might arise due to the use of aggregate price index which is constructed as the weighted average of individual price indices in a model. As firms may differ in their response to a particular shock, depending on various factors, the use of aggregate price is unlikely to reveal any asymmetry in the price adjustment of firms. More specifically, it is quite possible that some firms may exhibit asymmetry in price adjustment whereas others may not depending on the degree of price rigidity (as some prices are less flexible prices than others) which in turn may depend on size of menu costs and other factors (Balke and Wynne, 2004). It is also quite possible for a particular firm to respond asymmetrically to some kinds of disturbances whereas respond symmetrically to others (Kuran, 1983). Hence, the empirical studies based on *aggregated* price indices may quite often fail to reveal any asymmetry in price adjustment of firms and may lead to wrong inferences.

In this study, we examine whether there exists asymmetry in the price adjustment of firms while using the commodity wise whole sale price indices belonging to three different sectors - primary,

[2] Most of empirical studies in this line of literature have mainly focussed on vertical price transmission. For a survey of this literature see Peltzman, 2000.

manufacturing and fuel-power and lubricants – from India.[3] To this end, unlike the conventional manner of using linear regression models, we examine the price adjustment process of each firm separately in the threshold cointegration framework. We used the threshold autoregression (TAR) model as proposed by Enders and Granger (1998) and Enders and Siklos (2001). The advantage of this procedure is that it allows us to examine the price adjustment process of each firm in response to negative and positive deviations from equilibrium level. Further, it also allows examining the thresholds values between which a particular firm chooses inaction and allows its relative price to deviate in either direction from the equilibrium level. The rest of the paper is organised as follows. In section 2 of the paper the methodology is discussed in detail. In section 3 empirical results are presented and section 4 provides the concluding remarks.

MODELING ASYMMETRIC PRICE ADJUSTMENT WITHIN A COINTEGRATION FRAMEWORK

Unlike earlier studies, we examined the asymmetries in price adjustment in threshold error correction framework.[4] The advantage of modeling price adjustments in this framework is that it provides insights about short-run price adjustments in either direction. Also, the threshold error correction model make more appropriate as theoretical models predict nonlinear adjustments in response to positive and negative deviations (Mayer, 2004). Under this framework, first we test for cointegration by using standard cointegration tests. Next, we examine the asymmetries in the price adjustment process in error correction framework following the procedure of Enders and Granger (1998) and Enders and Siklos (2001).

[3]This is first attempt in this direction.

[4]Earlier studies have used simple linear regression models by first estimating the money equation and then examining the effect of monetary shocks on the output in piece wise linear regression (See Senda, 2001; Ravn and Sola, 2004)

Under Engle and Granger (1987) two-stage procedure, we first estimate a static cointegrating regression. Given the price series of commodity *i*, depicted as (P_{it}) and the general price (P_t), the cointegrating relationship can be represented as:

$$P_{it} = \alpha_i + \beta_i P_t + \varepsilon_{it} \tag{1}$$

Unlike the standard (Engle and Granger, 1987) approach which assumes that ε_{it} from Eq. (1) behave as an auto-regressive process in the form of:

$$\Delta\varepsilon_{it} = \rho_i \varepsilon_{it-1} + \mu_{it} \tag{2}$$

where ρ_i measures the speed of convergence of the system and μ_{it} is a white-noise disturbance, Enders and Granger (1998) and Enders and Siklos (2001) introduced asymmetric adjustment by letting ε_{it} to behave as a TAR process:

$$\Delta\varepsilon_{it} = \rho_{i1}(I_t)\varepsilon_{it-1} + \rho_{i2}(1-I_t)\varepsilon_{it-1} + \sum \psi_k \Delta\varepsilon_{it-k} + \mu_{it} \tag{3}$$

Where I_t is the indicator function such that:

$$I_t = 1 \quad if \;\; \varepsilon_{it-1} \geq \theta_i$$

$$or \;\; I_t = 0 \quad if \;\; \varepsilon_{it-1} < \theta_i$$

and θ_i is the threshold value of commodity *i*. As in the standard model, the residuals ε_{it} in Equation (1) measures the deviation of P_{it} from its equilibrium value defined as $P_{it}^* = \alpha_i^* + \beta_i^* P_t$, where α_i *and β_i * are the estimated values of α_i and β_i, respectively. In a particular case, where θ = 0, a positive deviation implies that a price is higher than its equilibrium (i.e., $P_{it} \succ P_{it}^*$) whereas a negative deviation implies that it is smaller than equilibrium price. Alternatively, in such a framework positive (negative) price deviation can be interpreted as rise (fall) in the relative price of a particular commodity.

Note that in the present study, there is no a priori reason to assume that the threshold is equal to zero. The underlying theoretical models suggest the use of error correction model with three regimes defined by two thresholds.[5] The advantage of using two thresholds is that the range between the two thresholds can be interpreted as the deviations from the long-run equilibrium, which compared to adjustment costs are so small that they do not trigger an adjustment process in the prices. Further, in such a framework we can also examine whether there exists asymmetry in threshold values; that is whether the value of positive threshold is greater than the absolute values of negative threshold for a particular commodity.

To find out the threshold values, the estimated residual series from the cointegrating regression are sorted in ascending order as suggested by Balke and Fomby (1997). The largest and smallest 15 percent of the values and also 15 percent of the values around the zero in the sorted residual series are discarded. In order to check the asymmetry in thresholds, two dimensional grid-searches is conducted to find the threshold value θ_{i1} for positive and θ_{i2} for negative deviations. In particular, we search for the lower threshold among negative error terms ($-\varepsilon_{it}$) and the upper threshold in the positive error terms ($+\varepsilon_{it}$). In this process, Eq. (3) is estimated by supplying all remaining values of residual series (ε_{it}). The value, among the positive (negative) range yielding the lowest residual sum of squares is retained as the appropriate upper (lower) threshold.[6]

[5]Earlier the studies such as Obstfeld and Taylor (1997), Goodwin and Piggott (2001), Serra and Goodwin (2002) and (Mayer (2004) have used two thresholds.

[6]Chan (1993) suggests that searching over the potential thresholds while minimizing the sum of squared errors from the fitted model yields super-consistent estimate of the threshold.

Given the existence of a cointegrating relationship and the threshold values (θ_{i1} and θ_{i2}), the error correction representation to capture the asymmetry in the price adjustment can be written as:

$$\Delta P_{it} = \gamma_i (I_t^{\,a})\varepsilon_{it-1} + \lambda_i (I_t^{\,b})\varepsilon_{it-1} + \eta_i (I_t^{\,c})\varepsilon_{it-1} + \sum \delta_{1k} \Delta P_{it-k} + \sum \delta_{2k} \Delta P_{t-k} + v_{it} \qquad (4)$$

where,

$$I_t^a = 1 \quad if \;\; \varepsilon_{it-1} \geq \theta_{i1}; \quad otherwise = 0$$

$$I_t^b = 1 \quad if \;\; \theta_{i2} < \varepsilon_{it-1} < \theta_{i1}; \quad otherwise = 0$$

$$I_t^c = 1 \quad if \;\; \varepsilon_{it-1} \leq \theta_{i2}; \quad otherwise = 0$$

Here, γ_i, λ_i and η_i are the adjustment coefficients, with respect to deviations greater than the threshold θ_{i1}, deviations in between θ_{i1} and θ_{i2}, and deviations less than θ_{i2}, respectively. As suggested by menu cost models, we expect γ_i and η_i to be significantly different from zero and η_i to be greater than γ_i. Also, λ_i is expected not to be significantly different from zero as it captures the adjustment process in response to those deviations for which menu costs are higher than benefits associated with adjusting the price to desired level. The advantage of choosing above specification is that under such framework, we can examine the nature of adjustment process within and outside the identified band of thresholds. As argued by Mayer (2004), in the presence of adjustment costs a model with three regimes separated by two thresholds makes more economic sense than a two regime model with only one threshold.

However, if λ_i for a certain commodity price is found to be significantly different from zero, we re-estimated the Equation (4) by using a single threshold θ as,

$$\Delta P_{it} = \gamma_i (I_t)\varepsilon_{it-1} + \eta_i (1 - I_t)\varepsilon_{it-1} + \sum \delta_{1k} \Delta P_{it-k} + \sum \delta_{2k} \Delta P_{t-k} + v_{it} \quad (5)$$

where I_t is the indicator function such that:

$I_t = 1 \quad if \;\; \varepsilon_{it-1} \geq \theta_i$

$or \;\; I_t = 0 \quad if \;\; \varepsilon_{it-1} < \theta_i$

In the above specification γ_i captures the speed of adjustment with respect price deviations above the threshold level (θ_i) whereas η_i captures the adjustments with respect to deviations below that threshold level. Here also, the value of θ_i is determined by following the grid search method as discussed above.

DATA AND EMPIRICAL RESULTS

To carry out empirical analysis, we used commodity wise whole sale price index (WPI) data which comprises of 435 commodities under three different categories: (i) Primary articles; (ii) Fuel, Power, Light, and Lubricants; and (iii) Manufactured Products. The complete time series covering the entire sample period, derived from a uniform definition on each price index were available on 419 commodities. The monthly data on these 419 commodity prices for the period from April 1993 to August 2010 is used. The data on WPI and their respective weights is collected from the website of Office of the Economic Advisor, Ministry of Commerce and Industry, Government of India.

To begin with, we examined the time series properties of the aggregate price index and its components by using the conventional Augmented Dickey-Fuller (ADF) and Phillips–Perron (PP) unit root tests. The test statistics (not presented here) indicate that the null hypothesis that the particular price series has unit root cannot be rejected at levels in any case whereas while considering each price series in first difference the null of unit root is rejected; suggesting that the individual commodity prices as well as aggregate price follow I (1) process.

Since all the price series are found to be I (1) process, we proceed to test for cointegration using Enders and Granger (1998) and Enders and Siklos (2001). In each case, the results from cointegration test suggest that null of no cointegration between aggregate price and a particular commodity price is rejected at conventional levels of significance. This indicates that individual prices and the general price move together in the long run. Once the cointegration is established we proceed to examine error correction mechanism to understand the short-run dynamics in price adjustment of firms.

First, we examined the error correction model while assuming inaction zone in the price adjustment of firms following the specification given in Equation (4). However, in most of the cases the results suggest that the loading coefficients, λ_i and γ_i, are not significantly different from zero. Therefore, we re-estimated the model by switching over to the specification given in equation (5). Nevertheless, in case of the commodity prices where the response for small and large price deviations differs the results obtained by using two thresholds were retained.

In Table 1, we present the results for top ten commodity price from the category of primary articles obtained by using the error correction representation given in Equation (5). In column two and three of the Table, the loading coefficients (η_i, γ_i) and the associated t-statistics are given. The results indicate that the null hypothesis that η_i is zero is rejected at the conventional level of significance in case of most of the commodities. This implies that firms adjust prices upwards quickly to correct the negative price deviation (i.e., when $P_{it} \prec P_{it}^*$). Whereas, the null of γ_i is zero is not rejected at the conventional level significance for any commodity prices presented here. These results indicate that the most of commodity prices from primary articles respond to correct only negative deviations from the equilibrium level and therefore implying strong asymmetry in favour upward adjustment. The average value of significant η_i in case of primary articles is- 0.15. This implies that on an average a particular price adjusts so as to eliminate about 15 percent of a unit change in the negative deviation from the equilibrium in the previous month. The results from most of the commodities belonging to the category of primary articles suggest that there exist strong asymmetry in the adjustment of prices.[7]

Table 1: Asymmetric Price Adjustment-Primary Articles

Commodity	η_i	γ_i	θ_i	τ_i
Barytes	-0.25 (-4.25)	-0.02 (0.39)	0.26	0.25
Cashewnuts	-0.24 (-3.92)	-0.04 (1.00)	-0.09	0.24
Asbestos	-0.22 (-4.32)	-0.04 (-1.30)	-0.14	0.22
Pineapple	-0.21 (-3.45)	-0.01 (-0.15)	0.14	0.21
Silica sand	-0.19 (-4.61)	-0.01 (-0.40)	0.56	0.19
Fish-Marine	-0.18 (-3.89)	-0.06 (-0.99)	0.11	0.18
Banana	-0.18 (-3.90)	-0.09 (-1.54)	0.13	0.18
Magnesite	-0.16 (-3.34)	-0.10 (-1.37)	0.66	0.16
Ochre	-0.16 (-3.66)	-0.02 (-0.46)	0.34	0.16
Betelnuts	-0.14 (-4.18)	-0.03 (-1.18)	0.23	0.14

Note: In parenthesis are t-values.

[7] Similar results are found for rest of the commodities. The results for remaining commodities can be obtained from the authors.

Further the positive value of threshold for most of commodities suggests that firms do not allow its relative price to fall below certain level and tries to maintain its price above the equilibrium level, The magnitude of the threshold value, for a particular commodity, indicates the minimum gap between the actual price and its equilibrium level required to trigger adjustment process. In other words, a soon as a particular relative price falls below certain level, the firms respond to correct it by adjusting its nominal price upwards. This result may be attributed to asymmetric profit function, which suggest that firms prefer to maintain their prices higher than the equilibrium level as it is less costly for a firm as compared to the situation when its price is lower than the equilibrium (Kuran, 1983; Ellingsen *et. al.*, 2006).

To examine the degree of asymmetry in price adjustment across firms we constructed a measure of asymmetry (τ_i) which is measured as the difference between absolute values of η_i and γ_i, that is $\tau_i = |\eta_i| - |\gamma_i|$. τ_i given in last column of the Table suggests that among primary articles higher degree of asymmetry is observed in Barytes followed by Cashew nuts.

Similar results were found for the commodity prices from the category of manufactured products. In Table 2, we present the results for top fifteen commodities belonging to the category of manufactured products.[8] As is evident from the column second of the Table, the the loading coefficient (γ_i) associated with positive deviations does not turn out to be significantly different from zero for most of commodities; implying that firms do not adjust prices downwards when their prices are higher than the equilibrium level. Whereas, η_i is found to significantly

[8] The results for the rest of the commodities can be obtained from the authors.

different from zero for most of the commodity prices. These results suggest that the prices adjust upwards to correct the negative deviation from the equilibrium whereas prices do not adjust downwards when they lie higher than equilibrium price. In other words, a particular firm chooses inaction and allows its price to lie above equilibrium price, indicating that there exists a strong asymmetry in the price adjustment of firms. Also, the presence of negative threshold in most of the commodities, as given in fourth column of the Table, implies that a particular firm allows its relative price to fall up to a certain level. Here also, the magnitude of the estimated threshold value for a particular commodity corresponds to the maximum negative price deviation that a particular firm tolerates. Any further deviation below such threshold triggers upward adjustment; implying that larger negative price discrepancies are less persistent. For example, the price of Building Bricks adjusts upwards once its relative price fall below -0.10. These threshold values seem to vary across commodities. Similar results were obtained from the commodity prices belonging to the category of fuel-power and lubricants (results not presented here).

Table 2: Asymmetric Price Adjustment - Manufactured Products

Commodity	η_i	γ_i	θ_i	τ_i
Terry Cotton Shirting	-0.33	-0.05	-0.02	0.33
	(-5.53)	(-0.86)		
Cotton Grey Cloth & Canvas	-0.29	0.01	-0.09	0.29
	(-7.47)	(0.09)		
Building bricks	-0.26	-0.06	-0.10	0.26
	(-5.30)	(-1.84)		
Switch gears	-0.24	-0.03	-0.08	0.24
	(-4.52)	(-0.99)		
Liquid oral other than vitamins	-0.24	-0.01	-0.09	0.24
	(-5.28)	(-0.35)		
Miscellaneous Cotton Cloth	-0.21	-0.04	-0.06	0.21
	(-3.92)	(-1.14)		
Roller Bearings	-0.21	-0.05	-0.06	0.21
	(-4.37)	(-1.64)		
Bidi	-0.20	-0.04	0.00	0.20
	(-4.76)	(-0.72)		
Zerda	-0.20	-0.01	-0.12	0.20
	(-4.68)	(-0.15)		
Fire bricks	-0.20	-0.01	-0.07	0.20
	(-4.55)	(-0.28)		
Butter	-0.19	-0.02	-0.04	0.19
	(-5.40)	(-0.85)		
Automobile Cables	-0.19	0.00	-0.06	0.19
	(-4.15)	(-0.01)		
Synthetic Cloth Dyed or Printed	-0.19	-0.02	-0.04	0.19
	(-3.95)	(-0.78)		
Skelps	-0.19	-0.07	0.03	0.19
	(-4.00)	(-1.16)		
Injection Ml. Plastic Items	-0.18	-0.01	-0.09	0.18
	(-3.86)	(-0.43)		

Note: In the parenthesis are t-values.

Finally, in Table 3, we have summarised the results obtained from all 418 commodities. The results indicate that for 52 percent of the commodity prices η_i turns out to be significantly different from zero whereas γ_i is significant for only 22 percent of commodity prices belonging to primary articles. More importantly, out of significant 52 percent of the commodity prices, for 51 percent of the commodity prices η_i is greater than γ_i. For the commodity prices from manufactured products, η_i turns to be significant for 68 percent of commodity prices whereas γ_i is significant for only 12 percent of commodity prices. Also, out of 68 percent of commodity prices with significant η_i, from the category of manufactured products, the results show that in case of 70 percent of commodity prices η_i is greater than γ_i indicating higher degree of asymmetry. In case of the category of fuel, power and lubricants, η_i is greater than γ_i for 60 percent of commodity prices.

Table 3: Summary Results

Commodity Category	$\eta_i \neq 0$ $\gamma_i = 0$	$\eta_i = 0$ $\gamma_i \neq 0$	$\eta_i \neq 0$ $\gamma_i \neq 0$	$\eta_i > \gamma_i$
Primary articles (87)	52	22	22	51
Manufactured products (314)	68	14	12	70
Fuel Power and Lubricants (18)	72	6	11	60

Note: All the figures in column 2, 3 and 4 are in percentages.

Overall, the results show that there exist strong asymmetry in the price adjustment of most of firms in the sense that firms adjust prices upwards when their prices are lower than the equilibrium level whereas they choose inaction when their prices are above the equilibrium level; thereby maintaining their relative prices above the equilibrium level. In other words, the results suggest that firms adjust their prices upwards when they lie below the equilibrium level whereas firms do not adjust downwards when they lie above equilibrium. Further, the results suggest that firms do not allow their relative prices to fall below certain threshold level. The threshold varies across firms and is positive for most of the primary articles and negative for manufactured products. The degree of asymmetry is found to be more pronounced in manufactured products than primary articles.

These empirical result provide strong evidence in favour of menu cost models of Sheshinski and Weiss (1977) and Ball and Mankiw (1994), which anticipate that in presence of menu costs and trend inflation, firms are less likely to adjust the prices downwards. Also, the results are consistent with the predictions of theoretical model based on asymmetric profit function (Kuran, 1983). More importantly, such asymmetry in pricing behaviour of firms is consistent with the asymmetric output effects of monetary shocks as documented by many empirical studies [DeLong and Summers (1988), Cover (1992), Karras (1996); Ravn and Sola (2004)]. Such asymmetry in price adjustment is an important source of asymmetric impact of of monetary policy shocks on output.

CONCLUDING REMARKS

Larger number of studies have provided evidence in favour of the view that monetary shocks have asymmetric effect on the output; that is negative shocks effect output more strongly than do the positive shocks of the same size. Ball and Mankiw (1994) argued that such asymmetric impact of monetary shocks originates basically from the asymmetries in the price adjustment of the firms. Most of the studies in the empirical literature, however, have focused mainly on asymmetric output effects of monetary shocks and ignored the underlying asymmetries in price adjustment of firms. In this backdrop, this study examines whether there exists asymmetries in the price adjustment of firms, as argued by Ball and Mankiw (1994, 1995). To carry out the empirical analysis we used commodity wise whole sale price index data from India.

The empirical results suggest that there exist a strong asymmetry in the price adjustment of the most of firms. More specifically, the prices adjust upwards to correct the negative deviation from the equilibrium level whereas downward adjustment to correct the positive price deviations does not occur. This implies that firms adjust prices in response to positive shocks to their desired prices whereas in response to negative shocks they adjust the level of output. The degree of asymmetry varies across commodities and is found to highest in primary sector. Further, the results suggest that there exist a certain threshold level for each firm below which a particular frim do not allow its relative prices to fall.

These results have crucial implications for the conduct of monetary policy. For example, in presence of such an asymmetry inflation control for monetary policy becomes not only more costly but also difficult. Any effort to increase the output by a positive monetary shock will result in increase in overall price level and leave output unchanged. Whereas in response to negative monetary shock, the output will fall and the price level will remain unaffected. These evidences imply that larger relative price variability can trigger inflation even in the absence of demand shocks.

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