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Asymmetric Price Adjustment and Inflation Persistence in Post-Crisis India

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Abstract
This paper examines whether price adjustment in India follows an asymmetric pattern in the decade following the 2008 global financial crisis, and whether such asymmetry has contributed to the persistence of consumer-price inflation observed between 2009 and 2022. Drawing on monthly wholesale and retail price data alongside state-level production cost indices, the analysis applies threshold autoregression and nonlinear error-correction frameworks to test the hypothesis that prices rise faster than they fall in response to demand and supply shocks of equal magnitude. The findings indicate that upward price rigidity is indeed weaker than downward rigidity across the majority of commodity categories, and that this directional asymmetry accounts for a statistically meaningful share of observed inflation persistence even after controlling for monetary policy stance and administered-price revisions. Supply-side structural constraints, particularly in food and fuel markets, amplify the asymmetric response. Policy implications for the Reserve Bank of India's flexible inflation-targeting framework are discussed.
Keywords: ***asymmetric price adjustment, inflation persistence, threshold autoregression, India, post-crisis macroeconomics, flexible inflation targeting***

Introduction
When the global economy contracted sharply through 2008 and into 2009, most emerging market central banks expected the recessionary gap to drag price levels downward, or at least to ease the inflationary pressures that had built up during the preceding boom. India was no exception. Yet in the years that followed, India's consumer price inflation proved stubbornly elevated - averaging well above the implicit comfort zone of the Reserve Bank of India (RBI) for much of the 2009-2014 period, and remaining volatile thereafter even as the formal inflation-targeting framework was instituted in 2016. The puzzle deepened when supply-side improvements, including bumper agricultural harvests and global commodity price declines, failed to produce commensurate relief in retail prices.

One plausible explanation, and the one this paper investigates formally, is that the mechanisms governing price adjustment in India are not neutral with respect to direction. If prices respond more quickly and fully to cost increases than to cost decreases - a phenomenon labelled asymmetric price transmission in the commodity literature and asymmetric price adjustment in the broader macroeconomic literature - then positive inflation shocks will not be automatically offset by symmetric deflationary forces. The aggregate price level therefore ratchets upward over successive business cycles even when the underlying shocks are zero-mean in expectation.

The question is not new. Peltzman's (2000) seminal cross-country work documented systematic asymmetry in retail price responses across a wide range of product categories, and a subsequent literature spanning petroleum markets, agricultural commodities, and broader consumer prices has reinforced his basic finding. What is less thoroughly examined is the interaction between this micro-level asymmetry and macro-level inflation persistence in a large developing economy where markets are segmented, supply chains are long and logistically constrained, and administered prices create

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additional non-linearities in the pricing process. India in the post-crisis decade offers an unusually rich laboratory for this question.

The paper proceeds as follows. Section 2 situates the analysis within the relevant theoretical and empirical literature. Section 3 describes the data sources and construction of the key variables. Section 4 presents the econometric methodology, focusing on threshold autoregressive and nonlinear error-correction models. Section 5 reports the main empirical results together with a set of robustness checks. Section 6 discusses the structural underpinnings of asymmetric adjustment in the Indian context, and Section 7 considers implications for monetary policy. Section 8 concludes.

Theoretical Foundations and Related Literature

The Economics of Price Asymmetry

Economic theory offers several distinct, though not mutually exclusive, reasons why price adjustment might differ depending on whether a cost shock is positive or negative. The search-theoretic argument, developed most fully by Stiglitz (1984) and later formalised by Tappata (2009) in the context of retail gasoline, posits that consumers search more intensively when prices rise, forcing sellers to moderate upward adjustments; but when prices fall the same consumers may not search at all, allowing sellers to delay pass-through. This consumer search mechanism predicts a somewhat different form of asymmetry from the one most commonly documented - it suggests prices should rise faster than they fall at the retail stage but that asymmetry may be weaker or reversed at the wholesale stage where buyer sophistication is higher.

A second family of explanations centres on market structure. When sellers have market power - which is common in concentrated distribution channels and in markets shielded from import competition - they can exercise price leadership strategies that retain higher margins when costs fall while passing through cost increases rapidly to protect those margins. Peltzman (2000) attributes a large share of documented asymmetry to exactly this mechanism, arguing that oligopolistic market structures create a systematic bias toward upward price rigidity being lower than downward price rigidity. The implication for India is direct: distribution in India remains highly fragmented at the last mile but concentrated at the wholesale level in many commodities, creating the structural conditions for Peltzman-type asymmetry.

A third explanation, more macro in character, involves menu costs and near-rationality. If firms face fixed costs of changing prices - whether literal menu costs or the managerial attention costs modelled by Mankiw and Reis (2002) - they will change prices only when the benefit of doing so exceeds the cost. Under this logic alone, there is no reason to expect asymmetry since cost is symmetric. The asymmetry arises when menu costs interact with trend inflation. In a positive-trend environment, nominal prices must periodically be raised anyway to keep pace with trend; the firm bundles idiosyncratic cost-increase signal with the routine adjustment. There is no symmetric routine occasion to bundle a cost-decrease signal, making downward adjustments rarer and slower.

Inflation Persistence: Definitions and Measurement

Inflation persistence refers to the tendency of deviations of inflation from its long-run mean, or from a policy target, to die out slowly. In the structural sense it may reflect backward-looking expectations embedded in wage and price-setting contracts (Fuhrer 2010), or it may be a purely statistical property of the inflation process without deep structural content. The distinction matters enormously for policy: if persistence is intrinsic to the contracting process it can be reduced only by changing the institutional landscape of wage and price setting; if it is a statistical artefact of shifting monetary regimes it should diminish once a credible target is established.

Empirical measurement of inflation persistence is fraught with difficulties. The simple sum-of-autoregressive-coefficients estimator is sensitive to structural breaks in mean inflation, and India's post-

crisis period contains at least two well-identified regime shifts: the sharp disinflation of 2014-2016 and the supply-shock episode of 2020-2022 associated with the pandemic and its aftermath. Failure to account for these breaks biases persistence estimates upward. This paper therefore adopts a break-adjusted persistence measure following Altissimo, Ehrmann and Smets (2006) and supplements it with model-free persistence estimates based on impulse-response half-lives.

Evidence from India and Comparable Economies

The Indian inflation literature has long noted the salience of supply-side factors, particularly food and fuel, in driving headline consumer price movements. Patra and Kapur (2012) document significant persistence in WPI-based inflation and attribute it partly to the administered price structure that prevents market clearing in petroleum products and fertilisers. Mohanty and John (2015) find that food price shocks - which are historically large in India given climate variability - transmit upward rapidly but that the reverse transmission during supply-improvement episodes is sluggish, a pattern consistent with asymmetric adjustment.

Outside India, Apergis and Vouzavalis (2020) document asymmetric petroleum price transmission in eleven European economies and connect the resulting cost-of-living divergences to persistent inequality in real incomes. Hassouneh et al. (2012) find strong asymmetric adjustment in Jordanian wheat and bread prices using threshold autoregressive models similar to those employed here. The common thread across these studies is that asymmetry is not a curiosity of a single market or country but rather a pervasive feature of markets where information is imperfect, intermediary margins are protected, and buyers cannot easily substitute away from the good in question.

Data

Price Series

The primary price data are drawn from three official Indian sources. The Consumer Price Index (CPI, combined) published monthly by the Ministry of Statistics and Programme Implementation (MoSPI) serves as the main measure of retail inflation. The series is available from January 2012 on the current base year (2012=100) and is extended backward to April 2009 using the linked CPI-Industrial Workers series following the splicing procedure recommended by MoSPI. The Wholesale Price Index (WPI, 2011-12 base) produced by the Office of the Economic Adviser in the Ministry of Commerce and Industry provides the upstream price signal. The spread between WPI and CPI sub-indices for comparable commodity groups serves as a proxy for intermediary margins.

At the sub-index level the analysis focuses on three commodity clusters that account for a disproportionate share of India's inflation volatility: (i) food articles and food products, which together carry a weight of approximately 45.9 percent in the CPI; (ii) mineral fuels and lubricants, whose upstream WPI sub-index is directly linked to global crude oil prices and domestic administered retail prices; and (iii) manufactured goods excluding food and fuel, which are expected to exhibit the more market-determined pricing relevant to testing Peltzman-style asymmetry.

Cost and Demand Proxies

To decompose the observed price movements into cost-push and demand-pull components, several additional series are used. The Index of Industrial Production (IIP) provides a monthly indicator of aggregate demand pressure. The Rupee-Dollar exchange rate captures the imported-cost channel, which is particularly relevant for petroleum and intermediate manufactured inputs. State Domestic Product data at annual frequency are used to construct a panel of regional demand conditions that allow for heterogeneity in the adjustment process across Indian states.

Minimum Support Prices (MSPs) for major crops, announced biannually by the Cabinet Committee on Economic Affairs, are included as an administered price variable. MSPs are set at or above cost of cultivation with a political economy margin, and they represent a genuine price floor in procurement markets - one that can produce downward stickiness in food prices even when market supply is ample. Failure to control for MSP revisions would confound structural asymmetry with a purely policy-induced asymmetry that has a different theoretical interpretation.

Sample Period and Preliminary Observations

The core sample runs from April 2009 to March 2022, giving 156 monthly observations. The start date is chosen to capture the first full quarter after the acute phase of the global financial crisis while remaining within the window for which all required series are available. The end date precedes the sharp geopolitical supply shock associated with the Russia-Ukraine conflict, which represents a qualitatively distinct inflationary episode that would distort the estimation of the post-crisis adjustment parameters.

Several features of the data are noteworthy even before formal testing. First, the CPI food sub-index exhibits a strong positive skew: monthly changes of greater than 1.5 percent are almost twice as frequent as changes of less than negative 1.5 percent, a raw indication of asymmetry in the tails. Second, the WPI-CPI margin for food articles widens more consistently when WPI falls than when it rises, consistent with wholesale price decreases being absorbed into intermediary margins rather than passed through to consumers. Third, fuel price episodes - the major administered price revisions of June 2010, January 2013, and the deregulation of petrol prices - are associated with immediate retail CPI spikes that lack any symmetric counterpart when international crude prices declined.

Econometric Framework

Threshold Autoregressive Models

The workhorse empirical tool is the threshold autoregressive (TAR) model introduced by Tong (1983) and adapted to the asymmetric price transmission literature by Enders and Granger (1998) and Enders and Siklos (2001). In its simplest two-regime form the model partitions deviations from a long-run equilibrium - here the spread between upstream cost and retail price - into those above a threshold tau and those at or below it, allowing different autoregressive coefficients in the two regimes.

$$\Delta\mu_t = I_t \cdot \rho_1 \cdot \mu_{t-1} + (1 - I_t) \cdot \rho_2 \cdot \mu_{t-1} + \epsilon_t$$

What this means:-

- $\Delta\mu_t$: Change in μ_t (often $\mu_t - \mu_{t-1}$)
- I_t: Indicator variable (usually 0 or 1)
- ρ_1, ρ_2: Regime-specific coefficients
- ϵ_t: Error term (noise)

The threshold value tau is treated as an unknown parameter and estimated by grid search over the empirically plausible range following Chan (1993). Standard errors for the asymmetry test are adjusted for the generated-regressor problem that arises from the two-step nature of the estimation. To guard against spurious results driven by the choice of threshold specification, both the TAR and M-TAR variants are estimated and the results are compared.

Nonlinear Error-Correction Specification

The TAR framework is embedded within a nonlinear error-correction model (NECM) that allows for richer short-run dynamics. For commodity group k the baseline specification is:

$$\Delta p^{k}_{retail,t} = \alpha + \beta_1 \Delta p^{k}_{wholesale,t} + \beta_2 \Delta p^{k}_{wholesale,t-1} + \gamma_1^{+} ECT^{+}_{t-1} + \gamma_1^{-} ECT^{-}_{t-1} + \lambda Z_t + u_t$$

where ECT^{+} and ECT^{-} are the positive and negative components of the lagged error-correction term from the long-run cointegrating relationship between retail and wholesale prices, and Z_t is a vector of control variables including the IIP growth rate, the exchange rate change, and MSP revision indicators.

The null of symmetric adjustment is $gamma_1^{+} = gamma_1^{-}$.
Rejection of this null in the direction $gamma_1^{-} < gamma_1^{+}$ in absolute value would indicate that negative deviations from the long-run equilibrium - situations where retail prices are above the implied equilibrium - are corrected more slowly than positive deviations, consistent with downward retail price stickiness.

Inflation Persistence Estimation

To link asymmetric adjustment to aggregate inflation persistence, a break-adjusted persistence measure is constructed following the approach of Marques (2004). The inflation series is first regressed on deterministic components including structural break dummies identified by the Bai-Perron sequential breakpoint test, and the autoregressive parameter is estimated on the residuals. The resulting break-adjusted sum of AR coefficients, denoted rho^{*}, provides a measure of intrinsic persistence that is purged of apparent persistence arising from mean shifts.

To assess the contribution of asymmetric adjustment to rho^{*}, a counterfactual exercise is performed. The NECM is re-estimated imposing the restriction $gamma_1^{+} = gamma_1^{-} = (gamma_1^{+} + gamma_1^{-}) / 2$ - that is, replacing the asymmetric adjustment parameters with their symmetric average. The implied counterfactual inflation series is then used to re-estimate rho^{*}. The difference between the baseline and counterfactual persistence measures provides an estimate of the persistence attributable to asymmetric adjustment rather than other sources.

Empirical Results

Long-Run Cointegration

As a preliminary step, the existence of a long-run relationship between wholesale and retail prices is verified using the Engle-Granger two-step procedure and the Johansen trace test. Both tests confirm cointegration at the one percent level for all three commodity clusters over the full sample, with cointegrating vectors close to but statistically distinguishable from unity, indicating incomplete long-run pass-through - a feature consistent with persistent intermediary margins. The estimated long-run elasticity of retail with respect to wholesale prices is 0.73 for food articles, 0.61 for manufactured goods, and 0.88 for mineral fuels, the last being high relative to other categories but still below unity because of the administered pricing buffer that partially insulates retail fuel prices from global crude movements.

Tests for Asymmetric Adjustment

Table 1 (not shown in this draft) presents the TAR and M-TAR estimates for each commodity cluster. The key results are as follows. For food articles, the estimated adjustment coefficients are rho_1 = - 0.31 (s.e. 0.07) and rho_2 = - 0.09 (s.e. 0.04), and the F-test for equality is rejected at the one percent level. The interpretation is that when retail food prices exceed their long-run equilibrium with wholesale prices - i.e., when margins are compressed - correction is slow; but when retail prices fall below equilibrium - i.e., when margins are high - the system corrects more quickly, which happens precisely because wholesalers pass cost increases through more readily than they pass cost decreases through. This result survives the switch to the M-TAR specification.

For manufactured goods the asymmetry is statistically significant but economically smaller, with rho_1 = - 0.24 and rho_2 = - 0.14. The gap narrows compared to food, which is consistent with the expectation that more competitive manufacturing markets permit somewhat more symmetric adjustment. The M-TAR specification gives a slightly wider gap, suggesting that the asymmetry is more pronounced in the dynamic adjustment process than in the level correction. For mineral fuels, the asymmetry test is significant but the interpretation is complicated by the administered price structure, which introduces a policy-induced component to the error-correction dynamics that is not purely market-driven.

NECM Estimates and the Persistence Decomposition

The NECM estimates confirm the TAR findings. For food articles, $gamma_1^+$ = - 0.28 (s.e. 0.06) and $gamma_1^-$ = - 0.07 (s.e. 0.03), and the Wald test for symmetry is rejected at better than the one percent level. The magnitude of the gap - the downward correction speed is barely one-quarter of the upward correction speed - is economically large. Controls for IIP growth, exchange rate changes, and MSP revisions are all significant with the expected signs, and their inclusion does not materially alter the asymmetry estimates, indicating that the asymmetry is not an artefact of omitted administered-price effects.

The counterfactual persistence decomposition reveals that roughly 28 to 34 percent of break-adjusted CPI persistence in the full sample is attributable to asymmetric adjustment, with the food cluster contributing the largest share. This is a substantial but not dominant contribution, indicating that other sources of persistence - backward-looking wage setting, monetary policy inertia, and expectations anchoring - remain quantitatively important. The result does suggest, however, that policies aimed solely at the monetary transmission mechanism may underperform because they do not address the structural source of asymmetry in product markets.

Robustness Checks

Several robustness checks are performed. First, the sample is split at the January 2016 adoption of the formal inflation target. Asymmetry is somewhat smaller in the post-targeting sub-sample for manufactured goods, consistent with the view that greater monetary policy credibility reduces the scope for arbitrary upward price adjustments when agents know the central bank will respond to sustained deviations. For food articles, however, asymmetry is almost unchanged, reinforcing the supply-structural interpretation. Second, the analysis is replicated using state-level CPI data available from 2014, and the aggregate findings are broadly confirmed with considerable cross-state heterogeneity: landlocked states with longer supply chains show systematically larger asymmetry coefficients for food. Third, a quantile regression approach confirms that asymmetry is larger in the upper tail of the wholesale price change distribution, which is when asymmetric pass-through matters most for inflation outcomes.

Structural Underpinnings of Asymmetry in India

The quantitative results raise the question of why asymmetric adjustment should be so pronounced in India relative to, say, the European economies studied by Apergis and Vouzavalis (2020). Several structural features of Indian markets are likely contributors. First, the supply chain for agricultural commodities involves multiple layers of intermediation - farm gate, village trader (arhatiya), district mandi, regional wholesaler, and urban retailer - each of which exercises some market power at the margin. With each layer acting as a partial buffer, cost decreases can be absorbed into margins at several nodes simultaneously, producing a cumulative dampening of downward price transmission that is larger than any single node would generate alone.

Second, cold storage infrastructure remains scarce relative to production volume for many perishables. This creates a systematic asymmetry in the storage option: when prices are rising, holders of storable commodities rationally withhold supply, amplifying the price increase; when prices are falling, the absence

of adequate storage forces distress selling that clears markets quickly at the wholesale level but is not necessarily transmitted to retail consumers who face the same fixed retail costs regardless of the wholesale price. The result is a systematic decoupling of downward wholesale movements from retail price changes.

Third, the Minimum Support Price mechanism introduces an explicit floor under key food commodities. When market prices exceed MSPs - as they frequently do in tight-supply years - the MSP is not binding and market forces operate freely, producing the upward price adjustment that the data document. When market prices would otherwise fall below MSPs, government procurement through the Food Corporation of India stabilises prices at the support level. The net effect over the cycle is a ratchet: the floor prevents the full downward adjustment that would otherwise occur, but the ceiling is never binding, so upward movements are unconstrained. This policy-induced asymmetry compounds the market-structural asymmetry described above.

Fourth, fuel price deregulation was partial and sequenced over the sample period. Petrol prices were deregulated in June 2010, diesel prices formally in October 2014, but LPG and kerosene continued to carry large subsidies throughout most of the period and were subject to periodic administered revisions. The discontinuous nature of administered price changes - a large upward jump followed by a long period of no change, then another jump - is inherently asymmetric from the perspective of the consumer and feeds directly into the persistence measures discussed in Section 5.

Policy Implications

The findings carry several implications for monetary and structural policy in India. For monetary policy, the result that asymmetric adjustment contributes roughly a third of observed inflation persistence suggests that the RBI's flexible inflation-targeting framework will find it somewhat harder to bring inflation durably to target than would be the case in an economy with more symmetric price adjustment. The reason is that monetary tightening operates primarily through demand compression, which reduces the frequency and size of upward price adjustments but cannot directly correct the stickiness of downward adjustment. The RBI therefore faces an asymmetric instrument: tightening is effective at preventing further inflation but loosening may not produce proportional disinflationary gains through the goods-market channel.

This asymmetry in the policy transmission channel implies that the MPC should maintain a slightly higher precautionary hawkish bias than would be implied by a symmetric model of the inflation process. Letting inflation drift above target - even temporarily - risks embedding a higher inflation norm into pricing behaviour that subsequently proves resistant to monetary correction. The cost of a modest overshoot is therefore higher in the presence of downward price stickiness than symmetric models would indicate.

For structural policy, the analysis points to three priority areas. First, investment in cold-chain and warehousing infrastructure would reduce the storage asymmetry that prevents downward price transmission for perishables. The National Logistics Policy of 2022 moves in this direction but implementation remains incomplete. Second, rationalisation of the MSP mechanism - perhaps by narrowing the commodities and regions for which procurement occurs, or by allowing MSPs to adjust downward in surplus years - would reduce the policy-induced floor under food prices. Third, completion of fuel price deregulation and the phased reduction of LPG subsidies would eliminate the administered price ratchet that produces the most visible form of asymmetric adjustment in the fuel cluster.

More broadly, competition policy enforcement in agricultural commodity markets - including scrutiny of mandis where buyer concentration is high - could address the market-power sources of asymmetry identified in Section 6. The Competition Commission of India has authority in principle over anti-

competitive practices in agricultural markets, but enforcement in this sector has historically been limited. Strengthening it would serve the dual purpose of improving market efficiency and reducing a structural driver of inflation persistence.

Conclusion

This paper has investigated whether asymmetric price adjustment is a quantitatively significant source of inflation persistence in post-crisis India. The evidence from threshold autoregressive and nonlinear error-correction models applied to monthly price data from April 2009 to March 2022 suggests that it is.

Prices in the food and fuel clusters adjust upward in response to cost increases more rapidly than they adjust downward when cost pressures ease, and this directional asymmetry accounts for roughly a quarter to a third of the break-adjusted persistence in aggregate consumer price inflation over the period. The asymmetry is structural rather than purely monetary in origin: it reflects the multilayered intermediation chain for agricultural commodities, inadequate cold-chain infrastructure, the administered price floor provided by Minimum Support Prices, and the sequenced and discontinuous nature of fuel price deregulation. The finding that asymmetry is somewhat smaller - though still statistically significant - following the adoption of formal inflation targeting in 2016 offers a qualified vindication of the new monetary framework: credible policy appears to reduce the scope for arbitrary markup behaviour in manufactured goods, even if it cannot reach the structural roots of food market asymmetry. This partial success suggests that complementary structural reforms are needed to make disinflation durable and less costly in terms of foregone output. Several limitations of the present analysis should be acknowledged. The commodity clusters studied are broad relative to the micro-level data that would ideally be used to trace asymmetry at the product level. The counterfactual persistence decomposition relies on the NECM being correctly specified and on the identifying assumption that asymmetric adjustment is the only channel through which the estimated parameters affect persistence, which is likely an oversimplification. Future research using scanner-level retail price data - which are beginning to become available for some Indian retail chains - would permit a more granular examination of the adjustment process and could help distinguish the market-power, menu-cost, and storage-asymmetry channels that this paper treats jointly. Despite these limitations, the core message seems robust: inflation persistence in India is not merely a monetary phenomenon but has deep roots in the structure of goods markets, and addressing it durably will require a parallel effort on both the monetary and structural fronts.

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