Research Square

Preprints are preliminary reports that have not undergone peer review.
They should not be considered conclusive, used to inform clinical practice,
or referenced by the media as validated information.

Asymmetric Cost Pass-Through and Pricing Power in Indian Manufacturing: The Role of Exchange Rate Volatility

S DARSHAN

sdarshan@rvu.edu.in

RV University

Research Article

Keywords: Asymmetric cost pass-through, pricing management, manufacturing prices, exchange-rate volatility, nonlinear autoregressive distributed lag, India

Posted Date: November 23rd, 2026

DOI: https://doi.org/10.21203/rs.3.rs-11692103/v1

License: This work is licensed under a Creative Commons Attribution 4.0 International License.
Read Full License

Additional Declarations: No competing interests reported.

Asymmetric Cost Pass-Through and Pricing Power in Indian Manufacturing: The Role of Exchange Rate Volatility

Abstract

This study examines asymmetric cost pass-through in Indian manufacturing by investigating whether increases and decreases in input costs have different short-run and long-run relationships with manufacturing prices and whether exchange-rate volatility has an additional independent association. Using monthly data from March 2016 to November 2022, the study constructs an aggregate relative price–cost proxy based on the manufacturing wholesale price index and West Texas Intermediate (WTI) crude oil prices converted into Indian rupees. The nonlinear autoregressive distributed lag (NARDL) framework is employed to distinguish positive and negative input-cost movements, with manufacturing activity growth included as a control variable. The findings establish a long-run relationship among manufacturing prices, input-cost movements, exchange-rate volatility, and manufacturing activity. Evidence of long-run asymmetry indicates that the relationship between manufacturing prices and input costs differs according to the direction of cost movements. However, the analysis does not establish statistically significant asymmetry in short-run adjustment. The error-correction results indicate gradual adjustment towards the estimated long-run relationship. Exchange-rate volatility exhibits no statistically significant additional long-run association with the relative price–cost proxy, whereas manufacturing activity growth demonstrates a negative and statistically significant association. These findings highlight the importance of considering the direction and persistence of input-cost movements when evaluating pricing adjustments. The study contributes to pricing-management research by examining asymmetric cost pass-through in the Indian manufacturing context and distinguishing short-run dynamics from long-run relationships. It also emphasises that aggregate price–cost movements should not be interpreted as direct evidence of firm-level pricing power, as pricing adjustments may reflect competitive conditions, contractual arrangements, inventory practices, and other cost-adjustment frictions.

Keywords: *Asymmetric cost pass-through; pricing management; manufacturing prices; exchange-rate volatility; nonlinear autoregressive distributed lag; India.*

1. Introduction

Manufacturing firms operate in an economic environment where changes in input costs do not necessarily translate into equivalent changes in output prices. Fluctuations in crude oil prices, energy expenses and exchange rates can alter production costs, requiring firms to balance cost recovery against demand conditions, competitive pressures and profitability objectives. When input costs rise, manufacturers may increase selling prices to protect their margins; however, when costs decline, price reductions may occur at a different pace or magnitude. This difference in price adjustment is commonly associated with asymmetric cost pass-through, whereby output prices respond differently to increases and decreases in input costs. Empirical evidence demonstrates that such asymmetry occurs across various markets, although its magnitude and direction depend on the economic setting and adjustment mechanisms (Borenstein et al., 1997; Peltzman, 2000). Accordingly, understanding manufacturing price movements requires examining whether the relationship between input costs and output prices changes with the direction and duration of cost movements.

Asymmetric price adjustment may emerge from several interconnected economic and operational factors, including inventory management, contractual arrangements, production schedules, price-adjustment costs and competitive conditions. Manufacturers may delay price revisions when cost movements are considered temporary or when changing prices could affect customer relationships.

Similarly, falling input costs may not immediately result in lower selling prices because firms must consider existing inventories, procurement commitments and prevailing market conditions. The literature establishes that asymmetric price transmission cannot be attributed exclusively to market power, as different adjustment patterns may also arise from information asymmetries, transaction costs and supply-chain characteristics (Meyer & von Cramon-Taubadel, 2004; Frey & Manera, 2007). Furthermore, the relationship may differ between the immediate response to a cost movement and the longer-term adjustment towards equilibrium. These considerations make it important to distinguish short-run dynamics from long-run relationships when investigating cost pass-through, particularly in the Indian manufacturing context.

The complexity of cost pass-through increases when manufacturers are exposed to international commodity prices and exchange-rate fluctuations. Crude oil represents a relevant traded-input benchmark because its price can influence energy, transportation and petroleum-related production expenses. In India, movements in the rupee–US dollar exchange rate can further affect the domestic-currency cost of internationally priced commodities. However, exchange-rate movements are not necessarily transmitted proportionately into domestic prices because firms operate under different competitive conditions and may adjust prices according to market-specific circumstances. Research demonstrates that exchange-rate pass-through varies across countries and product categories (Campa & Goldberg, 2005; Goldberg & Knetter, 1996), while international production networks can influence transmission through the sourcing and pricing of intermediate goods (Hagemejer et al., 2022). Evidence from Indian exports also highlights the importance of examining pass-through across different adjustment horizons (Mallick & Marques, 2010). Recent studies further reinforce this context-dependent perspective. Jalal and Gopinathan (2022) apply a multiple-threshold nonlinear ARDL framework to Indian data and report variations in exchange-rate effects on oil prices across quantiles and short- and long-run horizons. Cross-country evidence likewise indicates that input-price pass-through to output prices varies across economies (Aastha & Misra, 2026). Since the present study converts dollar-denominated West Texas Intermediate (WTI) crude oil prices into Indian rupees, exchange-rate movements are already incorporated into the input-cost measure. The separate exchange-rate-volatility variable therefore captures its additional conditional association with the outcome rather than the total effect of currency movements.

A further consideration concerns the measurement of pricing behaviour. Although pricing power generally refers to a firm's ability to sustain prices or markups under competitive conditions, aggregate price indices cannot directly establish the pricing power of individual manufacturers. The present study constructs its dependent variable as the difference between the logarithm of the manufacturing wholesale price index and the logarithm of rupee-denominated WTI crude oil prices. This measure represents an aggregate relative price–cost proxy, capturing the movement of manufacturing prices relative to a selected traded-input benchmark rather than directly measuring firm-level gross margins, markups or market concentration. Moreover, crude oil represents only one component of manufacturing costs, and its importance varies across industries with different production technologies and input requirements. The central research gap is therefore to examine whether positive and negative movements in this input-cost benchmark have different short-run and long-run relationships with the aggregate manufacturing price–cost proxy in India, while separately assessing the additional association of exchange-rate volatility.

The study addresses this research gap by examining whether increases and decreases in input costs have different relationships with manufacturing prices in India and whether exchange-rate volatility has an additional association with aggregate price–cost dynamics. By considering the direction of cost movements, the research provides a more nuanced understanding of how manufacturing prices respond

to changing input costs over time. It contributes to the pricing-management literature by highlighting the importance of asymmetric adjustment and distinguishing between the effects associated with rising and falling costs. The findings may also inform pricing decisions by encouraging manufacturers to consider the direction and persistence of cost changes rather than assuming that increases and decreases lead to equivalent price adjustments.

2. Literature Review and Hypothesis Development

The literature on cost pass-through and price adjustment examines how changes in production costs, commodity prices, and exchange rates are reflected in output prices over time. Although conventional pricing models provide a benchmark for understanding the relationship between costs and prices, actual adjustment may be affected by nominal price rigidity, information frictions, inventory decisions, contractual arrangements, and uncertainty about future costs. These mechanisms can cause prices to respond gradually or differently to increases and decreases in input costs (Rotemberg, 1982; Nakamura & Steinsson, 2008). Research on asymmetric price transmission further demonstrates that the direction, magnitude, and speed of price adjustment may differ across markets and economic conditions (Meyer & von Cramon-Taubadel, 2004; Frey & Manera, 2007). Similarly, exchange-rate pass-through research establishes that currency movements are not necessarily transmitted proportionately to domestic prices, because pricing decisions depend on factors such as currency denomination, market conditions, and the composition of imported goods (Goldberg & Knetter, 1996; Campa & Goldberg, 2005; Gopinath et al., 2010). Building on these insights, this study integrates price-adjustment cost theory and exchange-rate pass-through theory to investigate the relationship between Indian manufacturing prices, INR-denominated crude-oil costs, and exchange-rate volatility.

2.1 Asymmetric Cost Pass-Through and Long-Run Price Adjustment

The relationship between input costs and output prices is not necessarily proportional because firms may adjust prices gradually or respond differently to rising and falling costs. Price-adjustment cost theory explains that revising prices may involve administrative expenses, customer communication, contractual constraints, and uncertainty about competitors' responses. Firms may therefore postpone price revisions when the immediate benefits of adjustment are insufficient to justify the associated costs (Rotemberg, 1982). Empirical research on price setting provides further evidence that prices do not adjust continuously. Nakamura and Steinsson (2008), for example, document substantial variation in the frequency of price changes across consumer and producer goods, illustrating the importance of price rigidity in understanding observed price dynamics.

However, price rigidity alone does not establish asymmetric cost pass-through. Asymmetry occurs when the magnitude or speed of price adjustment differs according to the direction of an underlying cost movement. Peltzman (2000), examining a broad range of consumer and producer goods, finds that output prices frequently respond more rapidly to input-cost increases than to decreases. In the petroleum market, Borenstein et al. (1997) similarly identify asymmetric transmission between crude-oil prices and retail gasoline prices. Importantly, such asymmetry does not necessarily imply collusion or deliberate exploitation of market power. Tappata (2009) demonstrates theoretically that asymmetric pricing can emerge when consumers have incomplete information, even when firms behave competitively. The broader literature identifies several possible explanations, including information frictions, price-adjustment costs, market structure, and the organisation of distribution channels, while emphasising that the causes and empirical manifestations of asymmetry vary across settings (Meyer & von Cramon-Taubadel, 2004; Frey & Manera, 2007).

More recent evidence likewise indicates that asymmetry is market-specific. Rehman et al. (2025), studying oil-price shocks and energy markets with asymmetric ARDL models, find that long-run symmetry and short-run asymmetry differ across countries. Li and Guo (2022) also document nonlinear and threshold-dependent effects of oil-price shocks on inflation across BRICS economies. These findings support testing long-run and short-run symmetry separately in the present manufacturing-price setting. Such arguments are relevant to aggregate manufacturing prices because crude oil can influence production and distribution costs through energy consumption, transportation, and other indirect input channels. Changes in the cost of an internationally traded commodity may therefore be associated with changes in manufacturing prices, although the extent and timing of the response can vary across industries and periods. If increases in INR-denominated crude-oil costs have a different long-run relationship with manufacturing prices from decreases, the aggregate relative price–cost measure may exhibit long-run asymmetry. Nevertheless, findings from retail gasoline markets cannot automatically be generalised to aggregate manufacturing prices because the underlying products, production processes, and pricing mechanisms differ.

Moreover, an aggregate price–cost proxy should not be interpreted as a direct measure of firm-level markups, profit margins, or pricing power. It captures the movement of manufacturing prices relative to the selected input-cost benchmark rather than identifying the pricing behaviour of individual firms. This distinction is important because the presence of asymmetric price transmission is not, by itself, proof of market failure or market power (Meyer & von Cramon-Taubadel, 2004; Tappata, 2009). Accordingly, the present study tests whether the long-run relationships associated with positive and negative movements in the input-cost benchmark differ statistically in the Indian manufacturing context. The hypothesis is framed as a symmetry proposition because the direction and magnitude of any asymmetry must be established empirically.

Hypothesis 1 (H1): The long-run relationships associated with positive and negative input-cost movements are symmetric.

2.2 Short-Run Adjustment and Long-Run Asymmetry

Short-run price responses may differ from long-run relationships because firms cannot necessarily revise output prices immediately when input costs change. Price-adjustment costs and nominal price rigidity can produce staggered revisions, while inventories, existing supply agreements, and production cycles may delay the transmission of cost changes. Rotemberg (1982) provides a theoretical explanation for price rigidity, while Nakamura and Steinsson (2008) document empirical patterns in price-setting frequency and price increases and decreases. These findings suggest that the timing of a price revision is an important component of adjustment and that the immediate response to a cost shock may not represent the eventual relationship.

The distinction between adjustment speed and adjustment magnitude is particularly important. Prices may respond at different speeds to rising and falling costs even if their long-run relationships are similar; conversely, the initial responses may be statistically similar even when the long-run relationships differ. Evidence from petroleum markets illustrates the importance of examining adjustment dynamics rather than relying on a simple contemporaneous relationship between input and output prices (Borenstein et al., 1997). Broader reviews also show that asymmetric price transmission varies across products and empirical settings, and that conclusions depend partly on how asymmetry is defined and tested (Meyer & von Cramon-Taubadel, 2004; Frey & Manera, 2007). Furthermore, the theoretical analysis of Tappata (2009) indicates that information frictions can influence the dynamics of pricing responses, reinforcing the point that observed short-run adjustment need not be attributable to a single mechanism.

The nonlinear autoregressive distributed lag (NARDL) framework provides an appropriate empirical approach for investigating these differences because it decomposes changes in an explanatory variable into positive and negative partial sums and allows short-run and long-run symmetry restrictions to be evaluated separately (Shin et al., 2014). This approach builds on the autoregressive distributed lag and bounds-testing framework developed by Pesaran et al. (2001), which permits the examination of long-run relationships under specified integration conditions. The NARDL framework also provides dynamic multipliers that trace the adjustment following positive and negative shocks and show how short-run responses evolve towards their long-run relationships (Shin et al., 2014).

In the present study, this approach distinguishes the response of the manufacturing relative price–cost proxy to increases in INR-denominated crude-oil costs from its response to decreases. The short-run coefficients capture immediate and lagged responses, whereas the long-run coefficients describe the estimated long-run relationships associated with each direction of cost movement. This distinction is central to the research because evidence of long-run asymmetry does not necessarily imply short-run asymmetry. Temporary price rigidity may generate similar initial responses even when the long-run relationships differ, while different short-run responses may eventually converge to a symmetric long-run relationship. The framework therefore enables the study to evaluate the two forms of symmetry independently, rather than treating asymmetry as a single outcome. This separation also supports a more precise interpretation of the results: any detected asymmetry concerns the estimated relationship between the aggregate manufacturing price measure and the input-cost benchmark, not necessarily the price-setting decisions of individual manufacturers.

Hypothesis 2 (H2): The short-run responses associated with positive and negative input-cost movements are symmetric.

2.3 Exchange-Rate Pass-Through and Relative Price–Cost Dynamics

Exchange-rate pass-through theory explains how currency movements influence domestic prices through imported final goods, intermediate inputs, and internationally traded commodities. A depreciation of the domestic currency can increase the local-currency cost of imported inputs, but the extent to which this increase is reflected in output prices depends on pricing practices, industry composition, competitive conditions, and the time horizon considered. Goldberg and Knetter (1996) review evidence showing that exchange-rate movements do not necessarily translate proportionately into goods prices, while Campa and Goldberg (2005) document incomplete short-run pass-through into import prices and variation across product categories and countries. The currency in which goods are priced can also influence the degree of pass-through. Gopinath et al. (2010) show that exchange-rate pass-through differs substantially between goods priced in the importing country's currency and those priced in the exporting country's currency, highlighting the importance of price-setting arrangements. These findings suggest that the effects of currency movements depend not only on the magnitude of exchange-rate changes but also on how firms set prices and adjust them over time. In manufacturing, exchange-rate movements may affect the local-currency costs of imported materials and internationally traded energy, while uncertainty about future currency movements may influence procurement decisions, cost forecasting, and the timing of price revisions. Ji (2022) similarly demonstrates the relevance of distribution-chain structure to the transmission of exchange-rate changes into domestic inflation.

Recent syntheses support this context-dependent interpretation. Iorngurum (2025) finds substantial heterogeneity in exchange-rate pass-through estimates across countries and methods, with asymmetry and product characteristics also contributing to variation. Carrière-Swallow et al. (2025) further show that pass-through can depend on the state of the economy and the shocks driving exchange-rate movements. In a theoretical analysis, Shah and Garg (2026) also demonstrate that pass-through

dynamics depend on currency-pricing strategies and the nature of economic shocks. Evidence from India further supports examining exchange-rate pass-through in a context-sensitive manner. Bhat et al. (2024) investigate exchange-rate pass-through to Indian consumer prices using a smooth-transition model and find that pass-through differs across economic-activity regimes. Their results demonstrate that the relationship between currency movements and domestic prices may vary with macroeconomic conditions rather than remain constant across periods. Nevertheless, consumer-price pass-through and aggregate manufacturing relative price–cost dynamics are distinct outcomes, so evidence concerning one should not be treated as direct evidence concerning the other. These findings support treating the relationship between exchange-rate volatility and manufacturing price–cost dynamics as an empirical question rather than assuming a predetermined direction.

This distinction is particularly important in the present study because crude-oil prices are expressed in Indian rupees. The INR-denominated crude-oil cost benchmark already incorporates movements in international crude-oil prices and the INR/USD exchange rate. The separate exchange-rate-volatility variable is therefore intended to capture a possible additional long-run association with the manufacturing relative price–cost proxy, conditional on the local-currency input-cost measure. It should not be interpreted as the total effect of exchange-rate changes or as a moderating effect unless an interaction term is explicitly included in the model. Exchange-rate volatility may be associated with uncertainty in input costs and the timing of price revisions, but its relationship with the proxy could be positive, negative, or statistically insignificant. Accordingly, the present study tests whether exchange-rate volatility has a statistically significant long-run association with aggregate manufacturing price–cost dynamics. This formulation allows the analysis to assess the additional explanatory relevance of volatility without assuming a predetermined direction or claiming that the estimated relationship establishes causality.

Recent India-focused studies also highlight the relevance of uncertainty and macroeconomic conditions. Kumar and Rao (2026) examine whether economic-policy uncertainty influences exchange-rate pass-through to Indian consumer and wholesale prices, while Maheswari et al. (2026) study the role of exchange-rate uncertainty and report state-dependent pass-through. Singh and Kumar (2026) provide additional evidence on exchange-rate pass-through into domestic prices in India. Although these studies examine price outcomes distinct from the present aggregate manufacturing relative price–cost proxy, they reinforce the importance of considering uncertainty and economic conditions when investigating currency-related price adjustments. Taken together, the literature provides a basis for separately examining the conditional association between exchange-rate volatility and the aggregate manufacturing price–cost proxy while recognising that the direction, magnitude, and statistical significance of this relationship must be established empirically.

Hypothesis 3 (H3): Exchange-rate volatility has a statistically significant long-run association with the manufacturing relative price–cost dynamics.

3. Research Design

3.1 Sample and Data Sources

The analysis uses monthly observations covering March 2016 to November 2022, comprising a total of 81 monthly observations. The analysis combines a manufacturing price index, an international crude-oil benchmark, the INR/USD exchange rate, and a manufacturing activity indicator. All 81 observations are retained for the empirical analysis.

The manufacturing wholesale price index is identified by the series code WPIAMP01INM661N (manufacturing WPI, OECD/FRED). The exchange rate series is EXINUS (Indian rupees per US dollar), and the West Texas Intermediate crude-oil price series is MCOILWTICO (US dollars per barrel, US Energy Information Administration/FRED). Manufacturing production growth is represented by

INDPRMNTO01GPSAM (manufacturing production growth, seasonally adjusted). The final manuscript should retain the source-provider names and series identifiers consistently in the data appendix and references.

3.2 Variables and Measurement

This study examines the relationship between manufacturing prices, input-cost movements, and exchange-rate volatility in India using a monthly time-series framework. The variables are constructed to distinguish the long-run relationship between manufacturing prices and input costs from the potentially asymmetric responses to increases and decreases in input costs. The model also incorporates exchange-rate volatility and manufacturing activity to account for additional macroeconomic variation. All price and cost variables are transformed using natural logarithms where specified, allowing changes in the underlying series to be interpreted in proportional rather than absolute terms. The following subsections explain the measurement of the dependent variable, the input-cost decomposition, exchange-rate volatility, and the control variable, together with the derivation of the corresponding equations.

3.2.1 Measurement of the Manufacturing Relative Price–Cost Measure

The dependent variable is measured as the difference between the natural logarithm of the manufacturing Wholesale Price Index (WPI) and the natural logarithm of the INR-denominated West Texas Intermediate (WTI) crude-oil price. This measure captures the relative movement of manufacturing prices compared with a benchmark internationally traded input cost. The rationale for using the difference in logarithms is that it expresses the relationship between the two series in relative terms and reduces the influence of their different measurement scales. However, because crude oil represents only one component of manufacturing costs, the measure should be interpreted as an aggregate manufacturing relative price–cost measure, not as a direct firm-level measure of gross margins, markups, profitability, or market power.

The dependent variable is defined as:

$$PP_t = \ln(WPI_t^M) - \ln(OIL_t^{INR}) \quad \text{----------(1)}$$

where PP_t denotes the manufacturing relative price–cost measure at time t, WPI_t^M represents the manufacturing wholesale price index, and OIL_t^{INR} denotes the INR-denominated WTI crude-oil price.

The equation can be derived using the logarithmic identity:

$$\ln(A) - \ln(B) = \ln\left(\frac{A}{B}\right)$$

Therefore, Equation (1) can also be expressed as:

$$PP_t = \ln\left(\frac{WPI_t^M}{OIL_t^{INR}}\right)$$

This formulation indicates that the dependent variable represents the logarithm of the ratio between the manufacturing price index and the local-currency oil-price benchmark. An increase in PP_t indicates that manufacturing prices have risen relative to the oil-price benchmark, whereas a decrease indicates that manufacturing prices have fallen relative to it. Such movements do not necessarily imply changes in actual firm-level margins because the measure does not incorporate all production costs, firm-specific output prices, or firm-level sales and cost data.

3.2.2 Construction of the INR-Denominated Input-Cost Series

WTI crude oil is commonly quoted in US dollars per barrel, whereas the manufacturing price index used in this study reflects prices in the Indian economy. To maintain currency consistency, the international crude-oil price is converted into Indian rupees using the INR-per-USD exchange rate. WTI crude-oil prices are used as a benchmark for international energy-cost movements because changes in crude-oil prices can affect production and distribution costs and may subsequently be reflected in

manufacturing output prices. Previous research has documented asymmetric transmission of crude-oil price changes to downstream prices (Borenstein et al., 1997). Similarly, Ganapati et al. (2020) demonstrate that energy input-cost changes can be transmitted to manufacturing output prices, although the extent of pass-through varies across industries. Building on this literature, the present study uses WTI crude oil as an international input-cost benchmark to investigate the asymmetric relationship between input-cost movements and Indian manufacturing prices. Since WTI is quoted in US dollars per barrel, its conversion into Indian rupees also captures the combined influence of international oil-price movements and changes in the INR/USD exchange rate.

This transformation is important because changes in the domestic-currency cost of crude oil can arise from changes in the international oil price, movements in the exchange rate, or both.

The conversion is defined as:

$OIL_t^{INR} = WTI_t^{USD} \times EX_t$----------(2)

where $WTI_t^{USD}$is the WTI crude-oil price in US dollars per barrel and EX_t is the exchange rate expressed as Indian rupees per US dollar. The resulting OIL_t^{INR} is expressed in Indian rupees per barrel.

Taking the natural logarithm of both sides gives:

$\ln(OIL_t^{INR}) = \ln(WTI_t^{USD}) + \ln(EX_t)$----------(3)

The log input-cost series is consequently defined as:

$x_t = \ln(OIL_t^{INR})$----------(4)

Substituting x_t $value$ into Equation (1) gives:

$PP_t = \ln(WPI_t^M) - x_t$----------(5)

Equation (3) also shows that the change in the log INR-denominated oil price can be decomposed into the change in the log international oil price and the change in the log exchange rate:

$\Delta x_t = \Delta \ln(WTI_t^{USD}) + \Delta \ln(EX_t)$----------(6)

This decomposition demonstrates why exchange-rate movements are already reflected in the domestic-currency input-cost series. For example, if the international oil price remains unchanged while the rupee depreciates against the US dollar, the INR-denominated oil cost increases. Similarly, a decline in the international oil price may offset some or all of the increase caused by rupee depreciation. The resulting cost series therefore represents the combined movement of the international crude-oil price and the exchange rate.

3.2.3 Decomposition of Positive and Negative Input-Cost Changes

To investigate whether increases and decreases in input costs have different relationships with manufacturing prices, the study decomposes changes in the log input-cost series into positive and negative partial sums. This decomposition follows the nonlinear autoregressive distributed lag (NARDL) approach developed by Shin et al. (2014), which allows positive and negative movements in an explanatory variable to have different estimated effects.

The first step is to calculate the change in the log input-cost series:

$\Delta x_t = x_t - x_{t-1}$----------(7)

Because x_t is the logarithm of the INR-denominated oil price, Δx_t represents the change in log input costs. For small changes, this is approximately the percentage change in the domestic-currency oil price. Positive and negative changes are then separated using the maximum and minimum operators:

$\Delta x_t^+ = \max(\Delta x_t, 0)$----------(8)

$\Delta x_t^- = \min(\Delta x_t, 0)$----------(9)

The positive partial sum accumulates increases in the log input-cost series:

$INPUT_POS_t = \sum_{j=1}^{t} \Delta x_j^+ = \sum_{j=1}^{t} \max(\Delta x_j, 0)$----------(10)

The negative partial sum accumulates decreases:

$INPUT_NEG_t = \sum_{j=1}^{t} \Delta x_j^- = \sum_{j=1}^{t} \min(\Delta x_j, 0)$----------(11)

Under this definition, $INPUT_{POS_t}$ is non-negative and non-decreasing, while $INPUT_{NEG_t}$ is non-positive and non-increasing. The negative partial sum retains the negative sign of cost reductions; it should not be converted to an absolute value unless the model is explicitly redefined and estimated accordingly.

The decomposition enables the estimated model to distinguish the relationship associated with cumulative cost increases from the relationship associated with cumulative cost decreases. If the corresponding long-run coefficients differ statistically, the evidence supports long-run asymmetry. Similarly, differences between the short-run coefficients can be assessed to determine whether the adjustment process is asymmetric in the short run. Importantly, a negative coefficient on $INPUT_NEG_t$ does not automatically mean that cost reductions reduce manufacturing prices: interpretation depends on the sign convention, the estimated coefficient, and the direction of movement represented by the negative partial sum.

3.2.4 Measurement of Exchange-Rate Volatility

Exchange-rate volatility is measured using the absolute monthly change in the natural logarithm of the INR-per-USD exchange rate. The measure captures the magnitude of monthly exchange-rate movements without distinguishing between rupee appreciation and depreciation. This is appropriate for an indicator of exchange-rate movement intensity, although it is not a conditional variance measure derived from a volatility model.

The log exchange-rate change is first calculated as:

$\Delta \ln(EX_t) = \ln(EX_t) - \ln(EX_{t-1})$----------(12)

Exchange-rate volatility is then defined as:

$FX_VOLATILITY_t = |\Delta \ln(EX_t)|$----------(13)

The absolute-value transformation makes the variable non-negative. A larger value indicates a greater proportional exchange-rate movement during the month, regardless of whether the rupee depreciated or appreciated. A value of zero indicates no change in the exchange rate between the two monthly observations.

The interpretation of this variable requires particular care because the INR-denominated oil-price series already incorporates the exchange rate. Accordingly, the coefficient on $FX_VOLATILITY_t$ represents an additional conditional association with the manufacturing relative price–cost measure after accounting for the input-cost series and other included variables. It should not be interpreted as the total effect of exchange-rate movements on manufacturing prices. Furthermore, because the measure is the absolute monthly change in the log exchange rate, it captures the magnitude of observed monthly movements rather than persistent volatility estimated through a GARCH-type or other conditional-variance model.

3.2.5 Control Variable: Manufacturing Activity Growth

Manufacturing activity is controlled for using the manufacturing industrial production growth series, denoted by $IIP_MANUF_GROWTH_t$. Manufacturing activity can be associated with price–cost dynamics because changes in production and demand conditions may influence capacity utilisation, input requirements, and firms' pricing decisions. Including this variable helps account for changes in manufacturing activity that may coincide with movements in input costs and manufacturing prices.

Where the series is calculated as the percentage growth rate of the manufacturing Index of Industrial Production, it can be expressed as:

$IIP_MANUF_GROWTH_t = \left(\frac{IIP_t - IIP_{t-1}}{IIP_{t-1}}\right) \times 100$----------(14)

where IIP_t denotes the manufacturing industrial production index at time t. This equation should be used only if it matches the construction of the prepared dataset. If the existing series uses a year-on-year growth rate, a log-difference measure, or an official published growth rate, the equation and

variable description should instead reflect that exact definition. The expected sign of the control variable is not imposed in advance because the association between manufacturing activity and the relative price–cost measure may depend on demand conditions, capacity utilisation, and input-cost movements.

3.2.6 Control variable

Manufacturing activity is included as a control variable to account for changes in domestic industrial conditions that may coincide with movements in manufacturing prices and input costs. It is measured using the manufacturing industrial production growth series, identified as IIP_MANUF_GROWTH in the dataset (series code INDPRMNTO01GPSAM). Changes in manufacturing activity may reflect shifts in production demand and broader industrial conditions, which may also be associated with manufacturing price–cost dynamics. Including this variable helps estimate the conditional relationship between input-cost movements and the manufacturing relative price–cost measure while accounting for variations in industrial activity. The variable is treated as a control rather than the principal explanatory variable, and its coefficient is interpreted as a conditional association within the specified monthly time-series model, not as a causal effect. For transparency and reproducibility, the data appendix should report the series provider, original series name, transformation, units, and date coverage consistently.

Table 1. Variable Description

Sl. No.	Variable	Description	Measurement	Symbol
Response variable				
1	Pricing Power	Represents the aggregate relative price–cost relationship in Indian manufacturing.	Natural logarithm of manufacturing WPI minus the natural logarithm of the INR-denominated WTI crude-oil price.	PP_t
Explanatory variables				
2	Positive Input-Cost Changes	Captures the cumulative effect of increases in the input-cost benchmark.	Partial sum of positive changes in the logarithm of INR-denominated WTI crude-oil prices.	$INPUT_POS_t$
3	Negative Input-Cost Changes	Captures the cumulative effect of decreases in the input-cost benchmark.	Partial sum of negative changes in the logarithm of INR-denominated WTI crude-oil prices.	$INPUT_NEG_t$
4	Exchange-Rate Volatility	Measures the magnitude of monthly fluctuations in the INR/USD exchange rate.	Absolute monthly change in the natural logarithm of the INR/USD exchange rate.	$FX_VOLATILITY_t$
Control variable				
5	Manufacturing Activity Growth	Controls for changes in domestic manufacturing activity that may coincide with price and input-cost movements.	Manufacturing industrial production growth rate, using the selected seasonally adjusted series.	IIP_MANUF_GROWTH
Underlying input-cost series				

6	Input-Cost Benchmark	Represents the international crude-oil benchmark converted into Indian rupees.	WTI crude-oil price in USD per barrel multiplied by the INR/USD exchange rate.	OIL_t^{INR}

Source: Authors' calculations based on WTI crude-oil price data from FRED, manufacturing WPI from the Office of the Economic Adviser, DPIIT, INR/USD exchange-rate data, and manufacturing IIP from MoSPI

3.3 Empirical Model

The empirical analysis uses the nonlinear autoregressive distributed lag (NARDL) framework to examine whether increases and decreases in the rupee-denominated input-cost benchmark have different short-run and long-run relationships with the manufacturing relative price–cost proxy. The positive and negative partial-sum variables enter separately, while exchange-rate volatility is included to estimate its additional conditional association and manufacturing industrial production growth is included as a control. The bounds-testing procedure is used to assess whether a long-run levels relationship is present (Pesaran, Shin, & Smith, 2001), and the asymmetric decomposition follows Shin, Yu, and Greenwood-Nimmo (2014).

The conditional error-correction representation is expressed compactly as:

$$\Delta PP_t = c + \rho PP_{t-1} + \theta^{+} INPUT_POS_{t-1} + \theta^{-} INPUT_NEG_{t-1} + \gamma FX_VOLATILITY_{t-1} + \delta IIP_MANUF_GROWTH_{t-1} + \sum_{i=1}^{p} \phi_i \, \Delta PP_{t-i} + \sum_{j=0}^{q^{+}} \pi_j^{+} \, \Delta INPUT_POS_{t-j} + \sum_{k=0}^{q^{-}} \pi_k^{-} \, \Delta INPUT_NEG_{t-k} + \varepsilon_t$$

The study uses monthly time-series data from March 2016 to November 2022, comprising 81 monthly observations in the original dataset. The Nonlinear Autoregressive Distributed Lag (NARDL) model is employed to examine whether increases and decreases in input costs have different relationships with the manufacturing relative price–cost measure in the short run and long run. Unlike a conventional linear ARDL model, the NARDL framework decomposes input-cost changes into positive and negative partial sums, allowing asymmetric adjustment to be investigated. It also distinguishes short-run dynamics from long-run relationships and enables bounds testing for cointegration, provided that none of the variables is integrated of order two, I(2) (Pesaran et al., 2001; Shin et al., 2014). Accordingly, the model examines the asymmetric relationships between INR-denominated crude-oil prices and the manufacturing relative price–cost measure while accounting for exchange-rate volatility and manufacturing activity.

The study employs the Nonlinear Autoregressive Distributed Lag (NARDL) model to examine the asymmetric relationship between input-cost changes and the aggregate relative price–cost proxy, while accounting for exchange-rate volatility and manufacturing activity. The dependent variable, PP_t, represents the aggregate relative price–cost proxy, calculated as the logarithm of India's manufacturing Wholesale Price Index (WPI) minus the logarithm of WTI crude-oil prices converted into Indian rupees. The first-differenced dependent variable, ΔPP_t, captures monthly changes in this proxy. The independent variables $INPUT_POS_t$ and $INPUT_NEG_t$ represent the cumulative positive and negative changes in the log of INR-denominated WTI crude-oil prices, respectively, allowing the model to distinguish between increases and decreases in the input-cost benchmark. Their first differences,

$\Delta INPUT_POS_t$ and $\Delta INPUT_NEG_t$, capture the corresponding short-run movements. $FX_VOLATILITY_t$ is measured as the absolute monthly change in the log of the INR-per-USD exchange rate, while $IIP_MANUF_GROWTH_t$ captures manufacturing activity growth and serves as a control variable. The intercept c represents the constant term, while ρ is the coefficient on the lagged dependent variable. The parameters θ^+ and θ^- capture the long-run level relationships associated with positive and negative input-cost changes, respectively, whereas γ and δ represent the conditional associations of exchange-rate volatility and manufacturing activity growth with the dependent variable. The coefficients ϕ_i capture the effects of lagged changes in the dependent variable, while π_j^+ and π_k^- capture the short-run effects of changes in the positive and negative input-cost components. The parameters p, q^+, and q^- denote the selected lag orders for the respective differenced variables, and ε_t represents the error term. The lagged level terms capture the long-run relationship, while the first-differenced terms account for short-run dynamics and adjustment. Long-run asymmetry is examined by testing whether the implied long-run coefficients, $-\theta^+/\rho$ and $-\theta^-/\rho$, are equal, while short-run symmetry is assessed by testing the equality of the relevant cumulative short-run effects. Since the INR-denominated WTI benchmark already incorporates exchange-rate movements, the coefficient on exchange-rate volatility measures only its additional conditional association with the dependent variable; it does not represent the total effect of exchange-rate movements or a moderating effect. Overall, the model evaluates whether increases and decreases in input costs exhibit different short-run and long-run relationships with the aggregate relative price–cost proxy, without treating this proxy as a direct measure of firm-level pricing power or profit margins.

4. Results

Table 2 Descriptive statistics

Variable	N	Mean	Std. Dev.	Min	Max
Pricing-power proxy	81	-3.6055	0.282	-4.2249	-2.4554
Log input cost	81	8.3112	0.3446	7.1393	9.1014
Positive input-cost changes	81	1.9832	1.2251	0.1939	4.1641
Negative input-cost changes	81	-1.3068	1.024	-2.9609	0
Exchange-rate volatility	81	1.0147	0.8731	0.0196	4.1336
Manufacturing activity growth	81	1.0584	13.2249	-57.5621	91.9786

Source: Author's Computation

Table 2 presents the descriptive statistics for the variables included in the study. The pricing-power proxy records a mean of -3.6055 and a standard deviation of 0.2820, indicating relatively limited variation in the manufacturing price–cost relationship over the observation period. The mean value of LN_INPUT_COST is 8.3112, with values ranging from 7.1393 to 9.1014. The positive input-cost component has a mean of 1.9832, whereas the negative component records a mean of -1.3068, reflecting the cumulative increases and decreases captured by the NARDL decomposition. Exchange-rate volatility has an average value of 1.0147, indicating that the magnitude of monthly currency movements varied throughout the study period. Manufacturing activity growth has a mean of 1.0584 but displays considerably greater dispersion, with a standard deviation of 13.2249 and a range extending from -57.5621 to 91.9786. These extreme observations should be checked against the original data series before the final estimates are reported. Overall, the descriptive results establish that the variables differ in their degree of variation and provide an initial overview of the data used for the subsequent stationarity tests and NARDL estimation.

Table 3. Augmented Dickey–Fuller (ADF) Unit-Root Test Results

Variable	Level ADF Statistic	p-value	First-Difference ADF Statistic	p-value	Result
PRICING_POWER	-1.8515	0.353	-7.6209	0.000	I(1)
LN_INPUT_COST	-1.4204	0.568	-7.4849	0.000	I(1)
INPUT_POS	0.3945	0.981	-6.7487	0.000	I(1)
INPUT_NEG	-0.0511	0.950	-5.969	0.000	I(1)
FX_VOLATILITY	-8.3282	0.000	—	—	I(0)
IIP_MANUF_GROWTH	-9.6453	0.000	—	—	I(0)

Source: Author's Computation

The ADF test results indicate that PRICING_POWER, LN_INPUT_COST, INPUT_POS, and INPUT_NEG are non-stationary at level but become stationary after first differencing. In contrast, FX_VOLATILITY and IIP_MANUF_GROWTH are stationary at level, as their p-values are below 0.05. The results therefore indicate a mixture of I(0) and I(1) variables in the dataset. This pattern supports proceeding with the NARDL bounds-testing procedure, provided that none of the variables is integrated of order two (I(2). Following Pesaran, Shin, and Smith (2001), the next step is to examine whether a statistically significant long-run relationship exists among the variables.

Table 4. ARDL Bounds Test Results

Significance level	I(0) lower bound	I(1) upper bound	F-statistic	Result
10%	2.303	3.22	4.9958	Cointegration
5%	2.688	3.698	4.9958	Cointegration
1%	3.602	4.787	4.9958	Cointegration

Source: Author's Computation

The bounds-test results show that the calculated F-statistic of 4.9958 exceeds the upper-bound critical value at the 1% significance level, providing strong evidence of a long-run relationship among the variables in the model. This suggests that the manufacturing relative price–cost proxy, positive and negative input-cost movements, exchange-rate volatility, and manufacturing activity move together over the long term. The finding supports the use of the NARDL framework to examine both long-run relationships and short-run adjustment patterns (Pesaran, Shin, & Smith, 2001). However, the bounds test does not establish that positive and negative input-cost changes have different effects; this requires a separate asymmetry test. The long-run coefficients and Wald test are therefore examined in the following sections to determine the direction of the relationships and whether the differences are statistically significant.

Table 5. Long-Run Coefficient Estimates

Variable	Coefficient	Standard Error	t-Statistic	p-Value	Decision
INPUT_POS	−0.877573	0.019019	−46.142340	0.000	Significant at 1% level
INPUT_NEG	−0.932679	0.024134	−38.646290	0.000	Significant at 1% level
FX_VOLATILITY	0.000761	0.004637	0.164034	0.870	Not statistically significant
IIP_MANUF_GROWTH	−0.001706	0.000772	−2.208511	0.030	Significant at 5% level
Constant	−3.082785	0.012393	−248.743100	0.000	Significant at 1% level

*p-values are in parenthesis. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively. Source: Author's computations using EViews.*

The long-run estimates indicate that both positive and negative input-cost components are statistically significant at the 1% level. INPUT_POS has a coefficient of −0.8776, while INPUT_NEG has a coefficient of −0.9327, suggesting different long-run responses to input-cost movements. This difference must be formally assessed using the Wald test (Shin, Yu, & Greenwood-Nimmo, 2014). Exchange-rate volatility is statistically insignificant (p = 0.8702), indicating no significant independent long-run association with the aggregate price–cost proxy. Manufacturing activity growth has a negative, statistically significant coefficient (−0.0017; p = 0.0303). These findings should be interpreted as conditional associations rather than causal effects. The results suggest potential long-run asymmetry, which is formally examined in Table 6, consistent with the literature on asymmetric price adjustment (Peltzman, 2000; Meyer & von Cramon-Taubadel, 2004).

Table 6. Short-Run Dynamics and Error-Correction Model (ECM)

Variable	Coefficient	HAC Standard Error	t-Statistic	p-Value	Decision
COINTEQ	−0.119889	0.021135	−5.672646	<0.001	Statistically significant; supports adjustment towards long-run equilibrium
D(PRICING_POWER(-1))	0.482037	0.071781	6.71539	<0.001	Statistically significant at 1% level
D(INPUT_POS)	−0.955465	0.008275	−115.4687	<0.001	Statistically significant at 1% level
D(INPUT_POS(-1))	0.481601	0.071287	6.755844	<0.001	Statistically significant at 1% level
D(INPUT_NEG)	−0.990889	0.006521	−151.9426	<0.001	Statistically significant at 1% level
D(INPUT_NEG(-1))	0.488158	0.071635	6.814466	<0.001	Statistically significant at 1% level

Source: Author's Computation

The error-correction coefficient is negative and statistically significant (−0.1199, p < 0.001), indicating adjustment towards the estimated long-run relationship. Its magnitude suggests that approximately 12% of the previous month's disequilibrium is corrected each month. Both current positive and negative input-cost changes have significant negative coefficients, while their lagged changes are positive and significant. This indicates that the short-run response develops over more than one period. However, the individual coefficients alone do not establish whether the overall short-run responses differ significantly. A formal Wald test is therefore required to assess short-run asymmetry, consistent with the NARDL framework (Shin, Yu, & Greenwood-Nimmo, 2014).

Table 7. Wald Test for Short-Run Asymmetry

Test Statistic	Value	Degrees of Freedom	p-Value	Decision
Wald t-statistic	−0.6905	68	0.492	Fail to reject H_0
Wald F-statistic	0.4767	(1, 68)	0.492	Fail to reject H_0

Wald Chi-square	0.4767	1	0.489	Fail to reject H_0

Source: Author's Computation

The Wald test results show that the p-values exceed the 5% significance level. Therefore, the null hypothesis of short-run symmetry cannot be rejected. This indicates insufficient statistical evidence that the short-run responses to positive and negative input-cost movements differ significantly. Although the individual short-run coefficients reported in Table 6 are statistically significant, their significance does not establish asymmetry between the two responses. The finding highlights the importance of distinguishing short-run adjustment from long-run asymmetry within the NARDL framework (Shin, Yu, & Greenwood-Nimmo, 2014).

Table 8. Diagnostic Test Results

Diagnostic Test	**Test Statistic**	**p-Value**	**Decision**
Breusch–Godfrey LM (2 lags)	F = 1.2697	0.287	No significant serial correlation
Breusch–Pagan–Godfrey	F = 4.3315	0.000	Heteroskedasticity present
Jarque–Bera	JB = 3.1387	0.208	Residual normality not rejected
Ramsey RESET	F = 0.4527	0.503	No significant evidence of functional-form misspecification

Source: Author's Computation

The Breusch–Godfrey test indicates no significant serial correlation (p = 0.2877), while the Jarque–Bera test does not reject residual normality (p = 0.2082). The Ramsey RESET test also shows no significant evidence of functional-form misspecification (p = 0.5034). However, the Breusch–Pagan–Godfrey test identifies heteroskedasticity (p = 0.0001). Accordingly, HAC/Newey–West standard errors are used for statistical inference. These robust standard errors adjust the estimated uncertainty but do not eliminate the underlying heteroskedasticity.

Table 9. Parameter Stability Tests

Stability Test	**Result**	**Decision**
CUSUM	Within 5% critical bounds	Parameter stability supported
CUSUM of Squares (CUSUMSQ)	Within 5% critical bounds	Parameter stability supported

Source: Author's Computation

Both CUSUM and CUSUMSQ remain within their respective 5% critical bounds, providing no evidence of significant parameter instability over the study period. This supports the stability of the estimated model, including across a period marked by substantial economic disruption.

Table 10. Summary of Hypothesis Testing

Hypothesis	**Test / Evidence**	**Test Statistic**	**p-Value**	**Decision**	**Conclusion**

H1: Long-run symmetry	HAC Wald test	F = 7.7339	0.007	Reject H_0	Significant long-run asymmetry exists
H2: Short-run symmetry	HAC Wald test	F = 0.4767	0.492	Fail to reject H_0	Insufficient evidence of short-run asymmetry
H3: Exchange-rate volatility has a significant long-run association	Long-run coefficient test	t = 0.1640	0.870	Fail to reject H_0	No statistically significant independent long-run association detected
H4: Significant adjustment towards long-run equilibrium	Error-correction term	t = −5.6726	<0.001	Reject H_0	Significant adjustment towards long-run equilibrium

Source: Author's Computation

The results reveal different patterns across the four hypotheses. The long-run Wald test rejects symmetry ($p = 0.0070$), indicating that the relationship between the aggregate price–cost proxy and positive versus negative input-cost movements differs over the long term. In contrast, the short-run test does not reject symmetry ($p = 0.4923$), suggesting insufficient evidence of a significant difference in immediate adjustment. Exchange-rate volatility has no statistically significant independent long-run association with the proxy ($p = 0.8702$). The negative and significant error-correction coefficient indicates adjustment towards the estimated long-run relationship. Overall, the findings distinguish long-run asymmetry from short-run adjustment, consistent with the NARDL approach to modelling directional responses (Pesaran et al., 2001; Shin et al., 2014).

5. Discussion

The findings provide evidence that the relationship between Indian manufacturing prices and the selected input-cost benchmark differs according to the direction of cost movements and the time horizon considered. Using monthly data from March 2016 to November 2022, the study employs the nonlinear autoregressive distributed lag (NARDL) framework to examine long-run relationships, short-run adjustment, and the additional association of exchange-rate volatility. The ARDL bounds test produces an F-statistic of 4.9958, exceeding the upper-bound critical value at the 1% significance level, thereby supporting the existence of a long-run relationship among the variables. However, the existence of a long-run relationship does not automatically establish asymmetric adjustment; this requires separate tests of the equality of the positive and negative input-cost coefficients (Pesaran et al., 2001; Shin et al., 2014). The results reveal significant long-run asymmetry but insufficient evidence of short-run asymmetry, highlighting the importance of examining both the direction and duration of input-cost movements. These findings contribute to understanding aggregate manufacturing price–cost adjustment in India, while recognising that the selected proxy does not directly measure firm-level pricing power.

The principal finding is the rejection of the null hypothesis of long-run symmetry, supported by a Wald F-statistic of 7.7339 and a p-value of 0.0070. The estimated long-run coefficients are −0.8776 for positive input-cost movements and −0.9327 for negative input-cost movements, and both are statistically significant. The statistically significant difference between these coefficients indicates that the long-run relationship between manufacturing prices and the rupee-denominated crude-oil benchmark differs between rising and falling input costs. This finding is broadly consistent with the asymmetric price-transmission literature. Peltzman (2000) documents asymmetric price adjustment across numerous product markets, while Borenstein et al. (1997) examine asymmetric responses to

crude-oil price changes in gasoline markets. The present study extends this literature to aggregate Indian manufacturing, although its findings are not directly equivalent to those from retail gasoline markets because the price measures and market settings differ. Price-adjustment cost theory and nominal price stickiness provide possible explanations for the observed asymmetry, as firms may delay price revisions because of administrative expenses, contractual commitments, inventory management, and customer relationships (Rotemberg, 1982). Industrial-organisation theory also suggests that competitive conditions influence firms' ability to reflect cost movements in selling prices (Dornbusch, 1985). Nevertheless, the observed asymmetry does not establish market power as its sole cause, since transaction costs, information asymmetries, and supply-chain characteristics may also contribute (Meyer & von Cramon-Taubadel, 2004; Frey & Manera, 2007).

In contrast to the significant long-run result, the short-run Wald test produces an F-statistic of 0.4767 and a p-value of 0.4923, indicating that the null hypothesis of short-run symmetry cannot be rejected. This distinction is important because the statistical significance of individual short-run coefficients does not demonstrate that positive and negative input-cost movements have significantly different effects. The result qualifies the broader evidence of asymmetric pricing reported by Peltzman (2000) and Borenstein et al. (1997), demonstrating that asymmetry should not automatically be expected to occur equally across markets and adjustment horizons. One possible explanation is that manufacturers require time to incorporate persistent cost changes into their pricing decisions. Existing inventories, procurement agreements, production schedules, and customer contracts may delay the transmission of cost movements into manufacturing prices. The error-correction coefficient of −0.1199 is negative and statistically significant ($p < 0.001$), indicating adjustment towards the estimated long-run relationship. Its magnitude suggests that approximately 12% of the previous month's disequilibrium is corrected within one month, conditional on the model specification. However, this gradual adjustment does not establish that short-run correction differs according to the direction of input-cost movements. The findings therefore distinguish long-run asymmetry from the speed and symmetry of short-run adjustment, consistent with the NARDL approach developed by Shin et al. (2014).

Exchange-rate volatility has no statistically significant additional long-run association with the aggregate relative price–cost proxy, with a test statistic of 0.1640 and a p-value of 0.8702. This result should be interpreted in the context of how input costs are measured. The WTI crude-oil price is converted into Indian rupees, meaning that the input-cost benchmark already incorporates the INR/USD exchange rate. Consequently, the estimated volatility coefficient captures its additional conditional association after accounting for the input-cost measure, rather than the total influence of exchange-rate movements on domestic input costs. This distinction is important when comparing the result with earlier exchange-rate pass-through studies. Campa and Goldberg (2005) investigate exchange-rate pass-through into import prices, while Goldberg and Knetter (1996) review evidence concerning the relationship between goods prices and exchange rates. The present study examines a different empirical question: whether exchange-rate volatility provides an additional long-run association after currency conversion has already been incorporated into the input-cost measure. The insignificant coefficient does not imply that exchange-rate movements are irrelevant to Indian manufacturing. Currency depreciation may still increase the domestic-currency cost of imported inputs, while volatility may influence firms through uncertainty, hedging costs, and procurement decisions. The evidence indicates only that an additional statistically significant long-run association is not established within the specified model.

This interpretation is consistent with recent evidence that cost transmission varies with market structure, uncertainty, and the type of price being examined. Aastha and Misra (2026) analyse input-cost pass-through to output prices across 28 countries, while Iorngurum (2025) synthesises cross-country estimates of exchange-rate pass-through. Rehman et al. (2025) further demonstrate that asymmetric oil-price transmission differs across energy markets. These studies provide broader context for understanding why the direction, magnitude, and timing of cost transmission may vary across economic

settings. The present study complements these contributions by examining an aggregate Indian manufacturing relative price–cost proxy and distinguishing long-run asymmetry from short-run symmetry. Its findings therefore extend the discussion beyond whether cost transmission is asymmetric in general to consider whether such asymmetry persists over the long run and whether exchange-rate volatility has an additional association after the currency component is incorporated into the input-cost measure.

Manufacturing activity growth also exhibits a negative and statistically significant long-run association with the aggregate relative price–cost proxy. This finding suggests that, conditional on the other variables, higher manufacturing activity growth is associated with a lower value of the proxy. Several explanations are plausible. Greater production activity may be associated with improved capacity utilisation or production efficiencies, while stronger competition may constrain the extent to which manufacturers adjust output prices. However, these mechanisms are not directly tested by the present model; therefore, the coefficient should be interpreted as a conditional association rather than a causal effect. This result broadens the interpretation of cost pass-through by indicating that manufacturing price–cost relationships may be associated with operating conditions as well as changes in input costs. It also reinforces the relevance of industrial-organisation theory, under which pricing outcomes depend on market conditions and firms' capacity to adjust prices (Dornbusch, 1985). Nevertheless, the aggregate measure does not identify whether the observed association results from capacity utilisation, changes in demand, competitive pressure, or differences in firms' cost structures. Further research using sector-level or firm-level observations could investigate these possible explanations and assess whether the relationship varies across industries with different production technologies and import dependencies.

Overall, the study contributes to the literature by demonstrating that the direction of input-cost movements and the time horizon of adjustment are important for understanding aggregate manufacturing price–cost relationships in India. The significant long-run asymmetry is consistent with previous research on asymmetric price transmission, whereas the absence of statistically significant short-run asymmetry provides a more qualified conclusion for the Indian manufacturing context. Similarly, the insignificant additional association of exchange-rate volatility highlights the importance of distinguishing currency effects embedded in the input-cost measure from the separate contribution of volatility. For managers, the findings suggest that pricing reviews should consider the persistence and direction of input-cost movements alongside inventory positions, procurement commitments, competitive conditions, and currency exposure. Immediate price movements should not automatically be treated as evidence of the long-run response, and reductions in input costs should not be assumed to produce proportionate changes in output prices. Importantly, the findings do not establish that manufacturers systematically exploit cost increases or possess greater market power. The dependent variable represents an aggregate relative price–cost proxy rather than a direct measure of firm-level markups or margins. The principal conclusion is therefore that long-run directional differences and gradual adjustment characterise the estimated relationship, while short-run asymmetry and an additional long-run association of exchange-rate volatility remain statistically unestablished.

6. Conclusion

This study examined asymmetric cost pass-through in Indian manufacturing by investigating whether positive and negative movements in input costs have different short-run and long-run relationships with manufacturing prices and whether exchange-rate volatility has an additional independent association. Using monthly data from March 2016 to November 2022, the study employed the nonlinear autoregressive distributed lag (NARDL) framework to analyse the aggregate relative price–cost relationship, with manufacturing activity growth included as a control variable. The results establish a statistically significant long-run relationship among the variables and reveal significant long-run

asymmetry. However, the short-run symmetry hypothesis could not be rejected, indicating insufficient evidence that immediate adjustment differs significantly according to the direction of input-cost movements. The negative and statistically significant error-correction coefficient further indicates gradual adjustment towards the estimated long-run relationship. Exchange-rate volatility does not exhibit a statistically significant additional long-run association, whereas manufacturing activity growth has a negative and statistically significant conditional association with the relative price–cost proxy.

The principal contribution of the study is to demonstrate that the relationship between manufacturing prices and input costs should be examined across both adjustment horizons and directions of cost movement. The significant long-run asymmetry indicates that positive and negative input-cost movements are not associated with identical long-run relationships with manufacturing prices. This finding contributes to the asymmetric price-transmission literature by providing evidence from the Indian aggregate manufacturing context. Furthermore, the insignificant additional association of exchange-rate volatility highlights the importance of distinguishing the exchange-rate component already incorporated into rupee-denominated input costs from the independent association of volatility. These findings provide a more nuanced understanding of cost adjustment and reinforce the relevance of considering pricing frictions, competitive conditions, and the persistence of cost movements. Nevertheless, the results describe an aggregate relative price–cost relationship and should not be interpreted as direct evidence of firm-level pricing power or as proof of a specific causal mechanism.

Managers should monitor both the direction and persistence of input-cost changes when making pricing decisions. Pricing strategies should consider procurement costs, inventory levels, competitive conditions, and contractual rigidities rather than relying solely on immediate cost movements. Although exchange-rate volatility showed no significant additional association, firms should continue monitoring currency exposure because exchange-rate movements affect imported input costs.

The study uses aggregate monthly data from March 2016 to November 2022, limiting its ability to capture differences across firms and manufacturing industries. The relative price–cost proxy, based on manufacturing WPI and INR-converted WTI crude-oil prices, does not directly measure firm-level profit margins or markups. Furthermore, the aggregate analysis cannot fully identify the mechanisms underlying observed asymmetry, and the results should be interpreted as conditional associations rather than causal effects.

Future studies could use firm-level and industry-specific data to examine variations in cost pass-through across manufacturing sectors. Researchers may incorporate additional input costs, such as electricity, transportation, and intermediate goods, and investigate the roles of market concentration, inventory management, capacity utilisation, and contractual rigidities. Further research could also examine alternative exchange-rate volatility measures, different nonlinear econometric models, and periods of heightened economic uncertainty to test the robustness and generalisability of the findings.

Author contributions

The sole author conceptualized the study, developed the research framework, collected and analysed the data, interpreted the findings, and prepared the manuscript. The author reviewed and approved the final version of the manuscript.

Data Availability

The data used in this research were obtained from the OECD Main Economic Indicators database and the U.S. Energy Information Administration through the Federal Reserve Economic Data (FRED) database.

Clinical Trial Number

Not Applicable

Declarations

ChatGPT (GPT-6) and Grammarly were used for language editing, grammar correction, and improving the manuscript's readability. The authors take full responsibility for the content and findings.

Conflict of interest

The authors declare no competing interests.

Consent to participate

Not applicable.

References

Aastha, & Misra, S. (2026). Input costs' pass-through to output prices: a cross-country empirical analysis. *Macroeconomics and Finance in Emerging Market Economies*, *19*(2), 205-227.

Bhat, J. A., Nain, M. Z., & Bhat, S. A. (2024). Exchange rate pass-through to consumer prices in India–nonlinear evidence from a smooth transition model. International Journal of Finance & Economics, 29(1), 927-942.

Borenstein, S., Cameron, A. C., & Gilbert, R. (1997). Do gasoline prices respond asymmetrically to crude oil price changes?. The Quarterly journal of economics, 112(1), 305-339.

Campa, J. M., & Goldberg, L. S. (2005). Exchange rate pass-through into import prices. Review of Economics and Statistics, 87(4), 679-690.

Carrière-Swallow, Y., Firat, M., Furceri, D., & Jiménez, D. (2025). State-Dependent Exchange Rate Pass-Through. *Oxford Bulletin of Economics and Statistics*, *87*(3), 539-561.

Dornbusch, R. (1985). Exchange rates and prices (No. w1769). National Bureau of Economic Research.

Frey, G., & Manera, M. (2007). Econometric models of asymmetric price transmission. Journal of Economic surveys, 21(2), 349-415.

Goldberg, P. K., & Knetter, M. M. (1996). Goods prices and exchange rates: What have we learned?.

Gopinath, G., Itskhoki, O., & Rigobon, R. (2010). Currency choice and exchange rate pass-through. American Economic Review, 100(1), 304-336.

Hagemejer, J., Hałka, A., & Kotłowski, J. (2022). Global value chains and exchange rate pass-through—The role of non-linearities. International Review of Economics & Finance, 82, 461-478.

Iorngurum, T. D. (2025). The exchange rate pass-through to domestic prices: A meta-analysis. *Journal of Economic Surveys*, *39*(3), 1092-1124.

Jalal, R., & Gopinathan, R. (2022). Time-varying and asymmetric impact of exchange rate on oil prices in India: Evidence from a multiple threshold nonlinear ARDL model. *Finance Research Letters*, *50*, 103297.

Ji, J. (2022). Exchange rate pass-through to domestic inflation in a pricing model incorporating distribution chain structure. *Journal of Applied Economics*, *25*(1), 432-453.

Kumar, R., & Rao, D. T. (2026). Does Economic Policy Uncertainty Confound Exchange Rate Pass-through to Domestic Prices in India?. *Foreign Trade Review*, 00157325261420527.

Li, Y., & Guo, J. (2022). The asymmetric impacts of oil price and shocks on inflation in BRICS: a multiple threshold nonlinear ARDL model. *Applied Economics*, *54*(12), 1377-1395.

Maheswari, D., Sabu, S., & Ramachandran, M. (2026). Exchange rate pass-through to prices: the role of exchange rate uncertainty. *Journal of the Asia Pacific Economy*, 1-21.

Mallick, S., & Marques, H. (2010). Data frequency and exchange rate pass-through: Evidence from India's exports. International Review of Economics & Finance, 19(1), 13-22.

Meyer, J., & Von Cramon-Taubadel, S. (2004). Asymmetric price transmission: a survey. Journal of agricultural economics, 55(3), 581-611.

Nakamura, E., & Steinsson, J. (2008). Five facts about prices: A reevaluation of menu cost models. The Quarterly Journal of Economics, 123(4), 1415-1464.

Peltzman, S. (2000). Prices rise faster than they fall. Journal of political economy, 108(3), 466-502.

Pesaran, M. H., Shin, Y., & Smith, R. J. (2001). Bounds testing approaches to the analysis of level relationships. Journal of applied econometrics, 16(3), 289-326.

Rehman, M. U., Nautiyal, N., Alessa, N., Kashif, M., & Vo, X. V. (2025). Crude signals: Asymmetric adjustments in energy markets to global oil price shocks. Journal of Environmental Management, 391, Article 126567. https://doi.org/10.1016/j.jenvman.2025.126567

Rotemberg, J. J. (1982). Sticky prices in the United States. Journal of political economy, 90(6), 1187-1211.

Shah, S. A., & Garg, B. (2025). Dynamics of exchange rate pass-through: The role of pricing strategies and economic shocks. *Economic Modelling*, 107353.

Shin, Y., Yu, B., & Greenwood-Nimmo, M. (2014). Modelling asymmetric cointegration and dynamic multipliers in a nonlinear ARDL framework. In Festschrift in honor of Peter Schmidt: Econometric methods and applications (pp. 281-314). New York, NY: Springer New York.

Singh, M., & Kumar, M. (2026). Exchange Rate Pass-through into Domestic Prices: Evidence from India. *South Asia Economic Journal*, 13915614261477577.

Tappata, M. (2009). Rockets and feathers: Understanding asymmetric pricing. The RAND Journal of Economics, 40(4), 673-687.