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Explaining Indian Egg Price Dynamics: Seasonal Patterns, Feed Costs, and Diesel Prices, 2013–2025

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ABSTRACT: This study examines the primary determinants of CPI-adjusted monthly producer egg prices in India from January 2013 through December 2025. The analysis uses 156 monthly observations constructed from daily National Egg Coordination Committee city-level egg-price quotations. Explanatory variables include CPI-adjusted World Bank maize and soybean-meal benchmark prices, domestic diesel prices, a COVID-19-period indicator, a linear trend, and calendar-month fixed effects. Ordinary least squares regression models were estimated sequentially to assess the contribution of each group of variables. Models containing only feed prices, diesel prices, the COVID indicator, and trend explained little of the variation in producer egg prices, with the highest pre-seasonality R-squared equal to .046. The inclusion of month fixed effects substantially improved model performance: the final model explained 63.8% of monthly variation in CPI-adjusted producer egg prices, with an adjusted R-squared of .596. Producer egg prices were significantly lower than January prices in most months between February and October, with the largest reduction occurring in April. December prices were significantly higher than January prices. These results indicate that recurring seasonal variation is the dominant observed correlate of monthly producer egg-price movements. Among the non-seasonal variables, soybean meal was positively and statistically significantly associated with producer egg prices. Maize, diesel, the COVID-period indicator, and the linear trend were not statistically significant after controlling for seasonality and the other covariates. The findings should be interpreted as conditional associations rather than causal effects because the study uses aggregated observational data, global feed-price benchmarks rather than domestic farm-level feed prices, and a level-regression framework with mixed stationarity properties.

KEYWORDS: egg prices; poultry economics; India; seasonality; soybean meal; producer prices; time-series regression

1. INTRODUCTION

Eggs are an important and relatively affordable source of animal protein in India. Their price therefore matters not only to poultry producers and traders, but also to households, schools, nutrition programmes, and policymakers concerned with food affordability. India is one of the world's largest egg producers: national output reached approximately 149.11 billion eggs in 2024-25, with commercial poultry accounting for more than 84% of production (Department of Animal Husbandry and Dairying, 2025). Changes in producer egg prices can affect farm profitability, production incentives, consumer prices, and the stability of the wider poultry supply chain.

Despite the economic importance of egg prices, their monthly movement is not straightforward to explain. Poultry producers face changing feed costs, fuel costs, transport costs, weather conditions, disease risks, market arrivals, consumer demand, and broader economic disruptions. Maize and soybean meal are particularly relevant because they are major inputs in poultry feed. Diesel may affect the cost of transporting feed, chicks, eggs, and other production inputs. At the same time, egg prices may follow recurring seasonal patterns that are not captured by changes in input costs alone.

Previous studies of the Indian egg market have shown that prices are spatially connected across major markets but are not identical across locations (Saran & Gangwar, 2008; Sendhil et al., 2013). Other research has identified substantial seasonal variation in egg prices, including lower prices during spring or summer months and higher prices during late-year or winter months (Pradheeshwaran, 2025; Soumya, 2022). Research has also documented the disruption to India's poultry sector during COVID-19, when misinformation, restrictions on movement, labour shortages, and supply-chain interruptions affected poultry demand and production (Kolluri et al., 2021).

However, much of the existing literature focuses on a limited set of markets, nominal-price trends, price forecasting, seasonal decomposition, or market integration. Fewer studies jointly examine whether feed-price benchmarks, diesel prices, COVID-period disruption, trend, and calendar-month seasonality are associated with producer egg prices in one consistent monthly framework. This distinction is important because a variable that appears related to egg prices in isolation may no longer be important once seasonality and other market conditions are considered.

This study addresses that gap by analysing monthly producer egg prices in India from January 2013 through December 2025. It uses 156 monthly observations constructed from daily National Egg Coordination Committee city-level price quotations. The study combines these prices with World Bank maize and soybean-meal benchmark series, Petroleum Planning & Analysis Cell diesel prices, and the All-India Consumer Price Index. All price series are rebased to December 2025 using the CPI in order to reduce the influence of general inflation.

The study asks: What are the primary determinants of CPI-adjusted producer egg prices in India?

To answer this question, the analysis estimates a sequence of ordinary least squares regression models. The models progressively add CPI-adjusted maize prices, soybean-meal prices, diesel prices, a COVID-19 indicator, a linear trend, and calendar-month fixed effects. The final specification compares each month with January while controlling for the included input-price and time variables. Alternative one-month and two-month lagged feed-price models are also considered because changes in feed costs may affect production decisions with a delay.

The study makes four contributions. First, it uses a comparatively long monthly sample covering thirteen years, including the COVID-19 disruption and global commodity-price volatility of the early 2020s. Second, it focuses on CPI-adjusted rather than nominal price movements. Third, it separates maize, soybean meal, diesel, COVID, trend, and seasonality rather than attributing egg-price changes to only one visible factor. Fourth, it interprets the results cautiously as conditional associations rather than causal effects.

The analysis finds that seasonality is the dominant observed correlate of monthly producer egg-price variation. The final model, which includes month fixed effects, explains approximately 63.8% of the variation in CPI-adjusted producer egg prices, compared with less than 5% in the preceding model without month effects. Soybean meal is the only non-seasonal input-price variable that remains statistically significant in the final model. Maize, diesel, COVID, and the linear trend do not show statistically significant independent associations after seasonality and the other controls are included.

The remainder of the paper is organised as follows. Section 2 explains the Indian egg market and the economic mechanisms through which feed costs, diesel prices, COVID disruption, and seasonality may affect producer prices. Section 3 reviews the relevant literature. Section 4 describes the data, variables, and econometric methodology. Section 5 presents descriptive evidence, and Section 6 reports the regression and diagnostic results. Section 7 discusses the findings, Section 8 outlines the limitations, and Section 9 concludes.

2. INDIAN EGG MARKET AND ECONOMIC MECHANISMS

2.1 Structure of the Indian Egg Market

India's egg sector is economically important, geographically concentrated, and closely linked to the commercial poultry industry. In 2024-25, India produced approximately 149.11 billion eggs and ranked second globally in total egg production. Commercial poultry accounted for 84.49% of national egg output, while Andhra Pradesh, Tamil Nadu, Telangana, West Bengal, and Karnataka together produced 64.37% of India's eggs (Department of Animal Husbandry and Dairying, 2025). This concentration means that supply conditions in major producing states can influence prices beyond their immediate regions.

Producer egg prices are shaped by the interaction of production costs, flock and feed decisions, transport conditions, consumer demand, and seasonal changes in supply and consumption. However, price formation is not fully captured by any one input. Farmers may absorb part of an increase in costs through lower margins, alter feed formulations, adjust flock sizes over time, or face resistance from buyers when demand is weak. Consequently, higher costs of feed or fuel do not necessarily translate into an immediate, one-for-one increase in producer egg prices.

The present study uses monthly averages of daily National Egg Coordination Committee (NECC) city-level egg prices. These averages provide a broad national indicator of producer-price movements, but they do not represent every local market equally. The set of reporting cities changes over time, and the resulting national mean should therefore be interpreted as an unweighted indicator of average quoted producer prices rather than as a perfectly representative national transaction price.

2.2 Feed Costs: Maize and Soybean Meal

Feed is expected to be one of the most important cost components in commercial egg production. Maize is commonly used as an energy source in poultry diets, while soybean meal is a major protein source. Dinani et al. (2019) report that maize

commonly constitutes approximately 55-65% of poultry rations and soybean meal approximately 25-30%; therefore, the price and availability of these ingredients can materially affect feed costs.

The economic mechanism is straightforward. If the price of maize or soybean meal rises, feed manufacturers and poultry producers may face higher costs of producing eggs. Producers may then seek to recover part of the increase through higher egg prices. Yet the timing and size of pass-through are uncertain. Feed can be purchased in advance, producers may hold inventories, and egg prices also depend on seasonal demand and the number of laying hens already in production. Biological production cycles can further delay any relationship between changes in feed costs and egg prices.

This study uses World Bank Pink Sheet maize and soybean-meal series, measured in US dollars per metric ton. These are global commodity-price benchmarks, not direct measures of the prices paid by individual Indian poultry farms. They are useful indicators of international feed-market pressure, particularly during global commodity shocks, but their relationship with domestic Indian feed costs may be incomplete. Exchange-rate movements, trade policy, domestic harvest conditions, transport costs, and local market structure can all affect the extent to which global prices are transmitted to Indian producers.

For this reason, the maize and soybean-meal coefficients in the later regression analysis should be interpreted as associations between international, CPI-adjusted feed-price benchmarks and Indian producer egg prices. They should not be treated as direct estimates of the effect of a rupee increase in domestic feed costs.

2.3 Diesel Prices and Transport Costs

Diesel may affect egg prices through transportation and distribution costs. Feed ingredients must be transported from ports, processors, or domestic producing regions to poultry farms. Eggs must then be moved from farms to wholesalers, retailers, institutional buyers, and consumers. Higher diesel prices could therefore increase the cost of moving both inputs and finished eggs through the supply chain.

Nevertheless, diesel is likely to be a relatively indirect determinant of producer egg prices. Its effect may be small relative to the cost of feed, and transport costs may be shared among several stages of the value chain rather than fully passed back to producers. In addition, this study's diesel variable is an unweighted average of retail High Speed Diesel prices in Delhi, Mumbai, Kolkata, and Chennai. It is a consistent national proxy for broad fuel-cost conditions, but it cannot capture every regional freight market or the actual diesel expenditures of poultry farms.

The expected relationship between diesel and egg prices is therefore positive in theory, but potentially weaker and less immediate than the relationship between feed costs and egg prices.

2.4 Seasonality in Egg Prices

Seasonality is likely to be especially important in the Indian egg market. Egg demand and supply may vary systematically across the year because of weather conditions, changing dietary preferences, school and institutional demand, festivals, production cycles, and regional market conditions. These mechanisms may operate simultaneously. For example, hot weather may reduce consumer demand in some locations, while winter conditions may increase demand for eggs as an inexpensive and accessible source of protein.

Existing Indian evidence supports the expectation of substantial seasonal price variation. Using NECC data for 28 market centres from January 2013 to May 2024, Pradheeshwaran (2025) found that egg prices were lowest in April and highest in December, with higher prices during monsoon and winter periods and lower prices during summer. This pattern closely motivates the inclusion of month fixed effects in the present study.

Month fixed effects allow the regression model to compare each month with January while holding the included feed-price, diesel, COVID-period, and trend variables constant. They do not prove the exact cause of seasonal variation. Instead, they capture recurring calendar-month differences that may reflect several unobserved seasonal forces.

2.5 COVID-19 as a Temporary Market Disruption

The COVID-19 period introduced an unusual set of disruptions to India's poultry sector. In early 2020, misinformation linking poultry products with COVID-19 reduced consumer demand in some areas. Lockdowns subsequently disrupted transport, labour availability, feed access, hatchery operations, and the marketing of poultry products. Kolluri et al. (2021) describe substantial disruption to the Indian poultry value chain, including reduced consumption and demand, interruptions to feed and health-care supplies, and the destruction of eggs, chicks, and birds during the initial crisis.

The study therefore defines the COVID indicator as one from March 2020 through December 2021. March 2020 marks the beginning of severe nationwide disruption following India's lockdown, while the end of 2021 broadly marks the conclusion of the prolonged period in which pandemic restrictions and supply-chain effects remained unusually important. The dummy is not

intended to measure every consequence of the pandemic. Rather, it captures whether egg prices differed systematically during this exceptional period after accounting for the other variables in the model.

Overall, the expected determinants of producer egg prices are multidimensional. Feed prices may influence production costs; diesel may affect distribution costs; COVID-19 may capture temporary market disruption; and month effects may capture recurring seasonal conditions. The empirical analysis that follows evaluates which of these factors is most strongly associated with monthly real producer egg prices in India.

3. LITERATURE REVIEW

3.1 Egg Prices, Market Integration, and Price Formation in India

Egg prices in India are determined within a geographically dispersed but increasingly connected poultry market. Production is concentrated in several major states, while demand is distributed across urban and rural markets with different income levels, dietary preferences, and supply conditions. This structure creates the possibility that prices may move together across markets while still differing because of transport costs, local demand, regional production, and differences in market organisation.

Early research on Indian egg markets focused on spatial integration. Saran and Gangwar (2008) examined wholesale egg prices in six major markets using the Engle-Granger cointegration approach. They found evidence that these markets were cointegrated, suggesting that price information and market signals were transmitted across regions. However, they also noted that market integration does not guarantee that farmers in all locations receive identical prices or that every local market reacts at the same speed.

Sendhil et al. (2013) similarly investigated whether geographically separated Indian egg markets satisfied the law of one price. They found strong long-run integration among regional markets, but prices did not become identical across locations despite their common long-run movement. More recent work by Deepak et al. (2025) also found long-run cointegration among selected egg markets. This literature supports the use of a national monthly average as a useful summary indicator, while reinforcing the limitation that it cannot represent every producer or consumer market equally.

3.2 Seasonality, Weather, and Recurring Price Patterns

A consistent conclusion in the Indian egg-price literature is that seasonal variation is substantial. Seasonal price movements can arise through changes in consumer demand, weather-related production conditions, egg shelf life, school and institutional demand, festivals, regional arrivals, and broader changes in consumption patterns. These mechanisms may occur simultaneously; therefore, a seasonal statistical pattern should not automatically be attributed to one specific cause.

Pandian et al. (2011) analysed wholesale and retail egg-price movements in major South Indian markets using monthly NECC data. They found that prices typically reached their lowest levels around March or April and increased towards November-January. Soumya (2022) also found distinct seasonal patterns across Bengaluru, Chennai, Delhi, and Mumbai, although the timing of seasonal peaks varied among markets.

A broader study by Pradheeshwaran (2025) examined 28 Indian egg-market centres and found that egg prices were lowest in April and highest in December. The existing evidence therefore strongly justifies the inclusion of month fixed effects in the present study. These indicators control for recurring calendar-month differences in producer egg prices without assigning those differences to one unmeasured cause.

3.3 Feed Prices and Poultry-Production Costs

Feed costs are central to economic explanations of poultry prices. Maize is commonly used as the principal energy ingredient in poultry diets, while soybean meal is a major protein source. Dinani et al. (2019) report that maize commonly constitutes approximately 55-65% of poultry diets in India and soybean meal approximately 25-30%. Their availability and cost therefore strongly influence feed production costs.

The expected relationship is that increases in feed prices raise poultry-production costs and may eventually place upward pressure on egg prices. However, this pass-through need not be immediate or complete. Producers may use feed inventories, substitute ingredients where possible, alter flock-management decisions, or accept temporarily lower margins. Egg prices are also determined by market demand and the available supply of laying hens.

Ajjan et al. (2012) examined maize and poultry-market integration in India using cointegration and vector error-correction methods. They found evidence of price transmission from maize to poultry products. Their approach focused on market integration and adjustment rather than on a national regression that simultaneously controls for soybean meal, diesel prices, COVID disruption, time trend, and calendar-month effects. The present study therefore treats both maize and soybean meal as

separate explanatory variables while acknowledging that the measures are global benchmarks rather than direct farm-level feed prices.

3.4 Demand-Side, Social, and Geographic Determinants

Egg-price variation is not determined solely by production costs. Demand conditions also matter, and demand for eggs in India varies across income groups, social groups, rural and urban areas, and regions. Scudiero et al. (2023) analysed nationally representative household consumption data and found that egg and chicken consumption patterns were heterogeneous and associated with food-system factors, price, poultry-production concentration, urban location, religion, social group, and household characteristics.

This demand-side heterogeneity matters for producer prices because demand shocks may affect the ability of producers to pass higher costs through the supply chain. Since the present study does not include direct measures of household income, population, institutional demand, festivals, weather, or regional consumption patterns, month fixed effects serve as a partial control for recurring demand-side conditions rather than a complete explanation of them.

3.5 COVID-19 and Poultry-Market Disruption

COVID-19 created an unusual shock to India's poultry sector. The early phase of the pandemic was marked by misinformation linking poultry products to COVID-19, which reduced consumer demand in some markets. Subsequent lockdowns affected transport, labour availability, feed supply, hatchery activity, and the movement and marketing of poultry products.

Kolluri et al. (2021) documented the economic disruption experienced by the Indian poultry sector during the pandemic. Biswal et al. (2020) similarly concluded that COVID-19 and associated lockdowns affected livestock and poultry production systems, value chains, labour availability, marketing, and access to inputs. This evidence supports including a COVID-period indicator from March 2020 to December 2021, while recognising that a single dummy cannot identify every channel through which the pandemic affected prices.

3.6 Research Gap and Contribution of the Present Study

The reviewed literature provides strong evidence that Indian egg prices are spatially connected, seasonal, and influenced by wider poultry-market conditions. Studies of market integration have used cointegration and vector error-correction methods to examine price transmission across locations or between maize and poultry markets. Seasonal studies have decomposed prices or forecasted future prices using selected markets. Research on COVID-19 has documented a major disruption to poultry demand and supply chains.

However, the studies reviewed here do not jointly estimate the association of international maize and soybean-meal price benchmarks, domestic diesel prices, a COVID-period indicator, linear trend, and month fixed effects with a national monthly measure of real producer egg prices over January 2013-December 2025. The present study addresses this gap through a nested set of OLS models. Based on the literature, maize and soybean meal are expected to be positively associated with egg prices, diesel is expected to have a potentially weaker positive association, the COVID effect is uncertain, and seasonality is expected to explain a substantial share of variation.

4. DATA AND METHODOLOGY

4.1 Research Design and Sample

This study uses an observational monthly time-series design to examine the determinants of real producer egg prices in India. The sample covers January 2013 through December 2025, producing 156 monthly observations. The analysis investigates conditional associations between producer egg prices and international feed-price benchmarks, domestic diesel prices, a COVID-19-period indicator, a linear time trend, and seasonal month effects. Because the study uses non-experimental secondary data, the estimated relationships are interpreted as associations rather than causal effects.

All core variables were available for every month in the sample. No observations were deleted, interpolated, or otherwise modified for missing data. The first one or two values in the lagged variables are blank by construction because prior-month values do not exist at the beginning of the sample; these blanks do not indicate missing values in the core dataset.

4.2 Data Sources and Construction

Table 1 summarises the study variables, sources, frequencies, and construction procedures.

Table 1. Data sources and construction of variables

Variable	Original source	Frequency and construction	Unit
Producer egg price	National Egg Coordination Committee	Daily city-level prices; simple arithmetic mean of all available city-day quotations within each calendar month	₹ per 100 eggs
Maize price	World Bank Commodity Markets, Pink Sheet	Published monthly benchmark price series	US$ per metric ton
Soybean meal price	World Bank Commodity Markets, Pink Sheet	Published monthly benchmark price series	US$ per metric ton
Diesel price	Petroleum Planning & Analysis Cell	Daily HSD retail prices for Delhi, Mumbai, Kolkata, and Chennai; city-month means then equally weighted	₹ per litre
Consumer price index	MoSPI	All-India CPI, Combined Rural and Urban, General Index	Index

Note. Maize and soybean meal are global price benchmarks. HSD = High Speed Diesel; MoSPI = Ministry of Statistics and Programme Implementation.

The dependent variable is the monthly producer egg price. It was constructed as a simple arithmetic average of all daily NECC city-level prices available during each calendar month. The set of cities listed by NECC was not constant throughout the sample. Accordingly, the measure should be interpreted as an unweighted national indicator of quoted producer egg prices, rather than as a city-constant or transaction-weighted national price.

The maize and soybean-meal variables were obtained from the World Bank Commodity Markets Pink Sheet, which provides monthly international commodity benchmarks in US dollars per metric ton. These variables are therefore not direct measures of the rupee-denominated feed prices paid by Indian poultry farms. Rather, they represent global feed-market conditions that may be transmitted to Indian producers through trade, exchange rates, domestic supply conditions, and feed-mill pricing.

Diesel prices were taken from PPAC's daily retail High Speed Diesel series. For each calendar month, all daily observations were first averaged separately for Delhi, Mumbai, Kolkata, and Chennai. The four resulting city-level monthly averages were then combined using a simple unweighted arithmetic mean. The CPI series was the All-India Combined Rural and Urban General Index published by MoSPI.

4.3 Inflation Adjustment

To remove the influence of general inflation, all price variables were rebased to December 2025 values using the following formula:

CPI-adjusted price_t = Nominal price_t × (CPI_December 2025 / CPI_t).

For egg and diesel prices, this transformation produces prices expressed in December 2025 rupees. For maize and soybean meal, the transformation rescales the World Bank US$/metric-ton benchmarks using India's CPI. It does not convert the series into rupees. Therefore, maize and soybean meal should be understood as CPI-adjusted global US$/metric-ton benchmark prices, not as domestic Indian feed prices in ₹/quintal.

4.4 Variables

The dependent variable was the CPI-adjusted monthly producer egg price, measured in ₹ per 100 eggs. The principal explanatory variables were the CPI-adjusted maize benchmark, the CPI-adjusted soybean-meal benchmark, and the CPI-adjusted diesel price.

Three controls were included. First, a COVID-19 dummy equalled one from March 2020 through December 2021 and zero otherwise. Second, a linear trend variable was coded from 1 in January 2013 to 156 in December 2025. Third, eleven month dummy variables controlled for recurring calendar-month effects. January was omitted and therefore served as the reference category.

4.5 Descriptive and Preliminary Analysis

The analysis began with descriptive statistics for the four price series: mean, median, standard deviation, minimum, maximum, skewness, kurtosis, and coefficient of variation. Time-series plots were reviewed to identify broad trends, volatile periods, and visible seasonal patterns.

Pearson correlation coefficients were calculated among real egg prices, maize prices, soybean-meal prices, and diesel prices. Correlation analysis was used to describe bivariate relationships and identify potential multicollinearity, but it was not treated as evidence of independent price effects because it does not control for other prices, time trends, or seasonality.

4.6 Regression Specification

Ordinary least squares (OLS) regression was used to estimate the relationship between real producer egg prices and the explanatory variables. Six nested models were estimated in order to show how model fit and coefficient estimates changed as relevant controls were introduced. Model 1 included maize only; Model 2 added soybean meal; Model 3 added diesel; Model 4 added the COVID indicator; Model 5 added the linear trend; and Model 6 added eleven month fixed effects.

The final specification was $Egg_t = \alpha + \beta1Maize_t + \beta2Soymeal_t + \beta3Diesel_t + \beta4COVID_t + \beta5Trend_t + \Sigma\gamma mMonth_{m,t} + \varepsilon_t$, where January is the omitted reference month. The nested design allows the contribution of each group of variables to be assessed through changes in R-squared, adjusted R-squared, coefficient estimates, and statistical significance.

Alternative Models 7-10 used one-month and two-month lags of the feed-price variables while retaining the same general control structure. All tests were two-sided and evaluated at the 5% significance level. Results were reported with 95% confidence intervals where available.

4.7 Diagnostic and Time-Series Procedures

Normality of residuals was assessed using the Shapiro-Wilk test and a normal Q-Q plot. Linearity and the broad pattern of residual variance were assessed visually using residuals-versus-fitted plots and residuals-versus-predictor plots. Multicollinearity was assessed using variance inflation factors, and influential observations were assessed using Cook's distance.

The time-series properties of the price variables were assessed using Augmented Dickey-Fuller tests. Each ADF specification included both an intercept and a deterministic linear trend, with lag length selected automatically using the Akaike Information Criterion. The ADF test evaluates the null hypothesis that a series contains a unit root and is therefore non-stationary.

4.8 Software and Reproducibility

All descriptive statistics, correlations, OLS regressions, regression diagnostics, and graphical outputs were produced in jamovi. The study used publicly available secondary data. The compiled dataset and analysis materials can be made available by the author upon reasonable request.

5. DESCRIPTIVE RESULTS

5.1 Overview of the Sample

The final dataset contains 156 complete monthly observations from January 2013 through December 2025. It includes CPI-adjusted producer egg prices, CPI-adjusted World Bank maize and soybean-meal benchmark prices, and CPI-adjusted diesel prices. No core variable contains missing monthly observations.

Table 2 presents descriptive statistics for the four price series. Real producer egg prices averaged ₹549.86 per 100 eggs, with a median of ₹545.49 and a standard deviation of ₹63.55. The series ranged from ₹390.98 to ₹708.30 per 100 eggs. Its coefficient of variation was 11.56%, indicating moderate variation relative to its mean. The feed-price benchmarks were substantially more variable, whereas diesel was the least variable explanatory price series.

Table 2. **Descriptive statistics for CPI-adjusted monthly price variables, January 2013-December 2025**

Variable	N	Mean	Median	SD	Minimum	Maximum	Skewness	Excess kurtosis	CV (%)
Producer egg price (₹/100 eggs)	156	549.86	545.49	63.55	390.98	708.30	0.19	-0.47	11.56
Maize benchmark	156	276.22	249.79	82.41	174.73	580.00	1.72	3.33	29.83

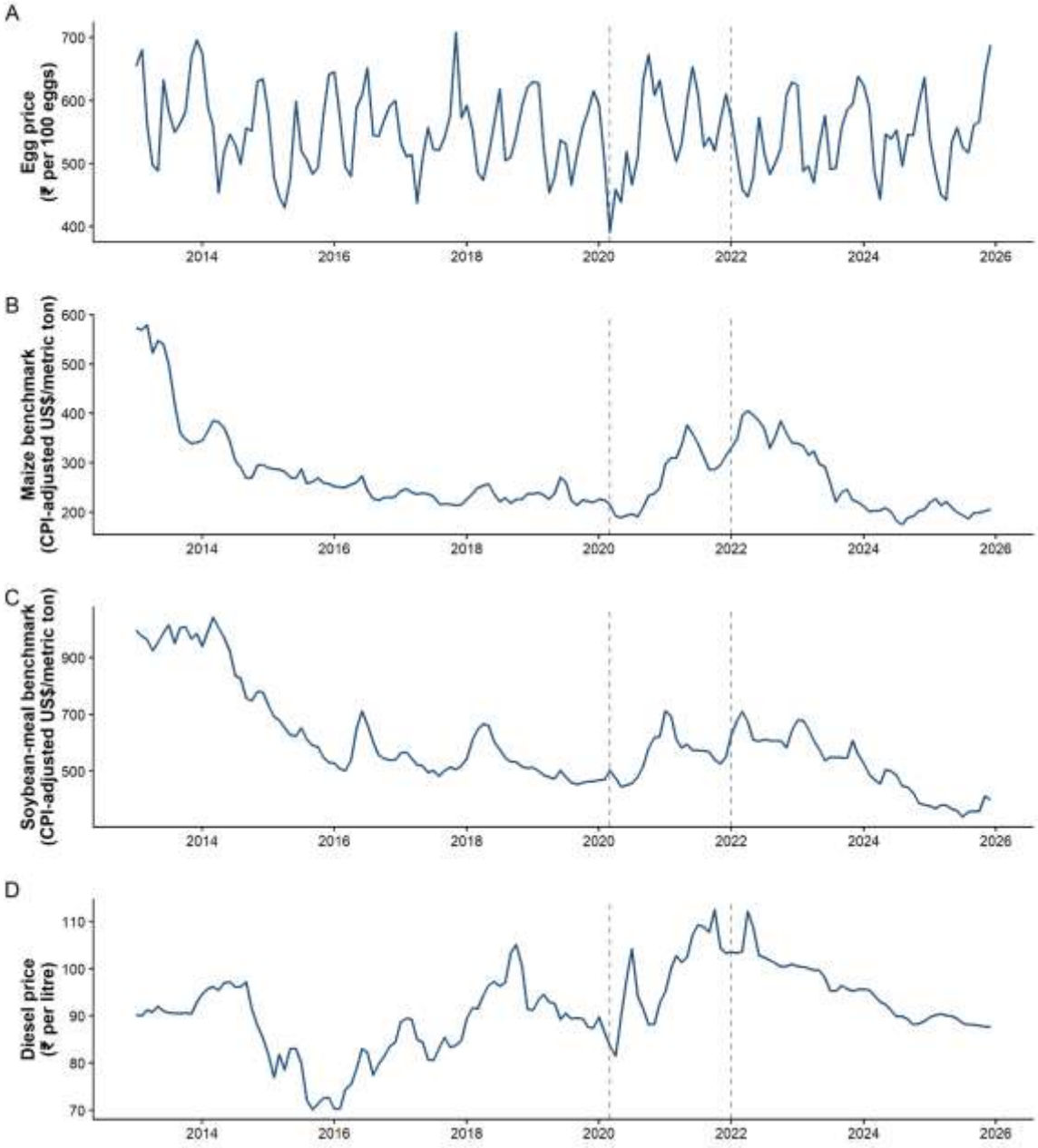
Variable	N	Mean	Median	SD	Minimum	Maximum	Skewness	Excess kurtosis	CV (%)
(US$/metric ton)									
Soybean-meal benchmark (US$/metric ton)	156	599.17	553.35	167.78	338.25	1,042.92	1.12	0.71	28.00
Diesel price (₹/litre)	156	91.47	90.72	8.74	70.18	112.54	-0.17	0.10	9.56

Note. CV = coefficient of variation. Kurtosis is reported as excess kurtosis. Maize and soybean meal are CPI-adjusted global US$/metric-ton benchmarks, not domestic farm feed prices. Source: Author's calculations from the compiled dataset.

5.2 Time-Series Patterns

The descriptive time-series evidence indicates that producer egg prices followed a recurring seasonal pattern rather than a simple long-run upward or downward path. Real egg prices were highest in November and December, with average prices of ₹613.29 and ₹631.94 per 100 eggs, respectively. The lowest average monthly price occurred in April, at ₹463.01 per 100 eggs. The overall minimum, ₹390.98 per 100 eggs, occurred in March 2020, coinciding with the beginning of major COVID-19-related disruption in India. The maximum, ₹708.30 per 100 eggs, occurred in November 2017.

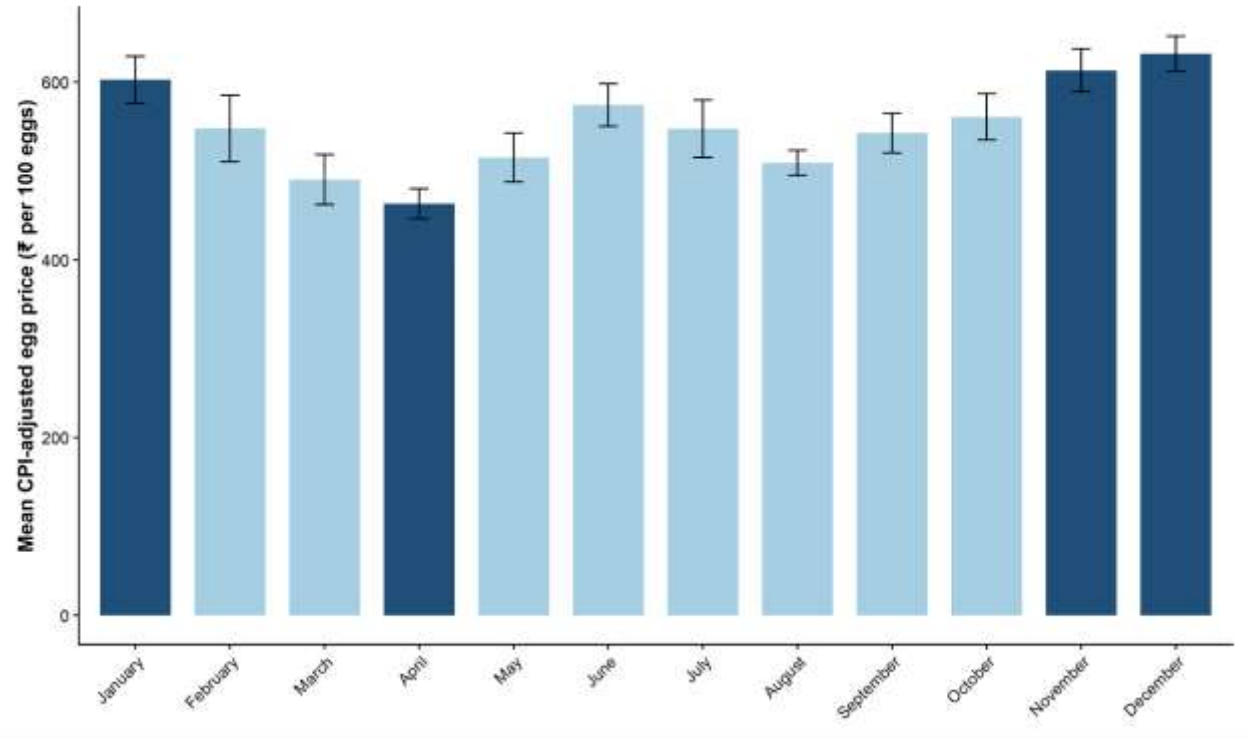
The maize and soybean-meal series displayed greater volatility than egg prices. Both feed-price benchmarks declined from their relatively high early-sample values, experienced renewed upward movements around 2021-2022, and then declined again. Diesel prices showed comparatively smooth movement, with a minimum of ₹70.18 per litre in September 2015 and a maximum of ₹112.54 in October 2021.



5.3 Seasonal Pattern in Producer Egg Prices

The monthly means provide descriptive evidence of substantial seasonality in real producer egg prices. Average prices were highest in December, November, and January. They fell sharply from January into February, March, and April, before recovering through May and June. Prices then remained lower than winter levels through much of July-October before increasing again late in the year.

This seasonal pattern is consistent with the descriptive literature on Indian egg prices. However, the descriptive pattern alone does not establish why these month-to-month differences occur. They may reflect changing consumer demand, weather, production cycles, institutional demand, market arrivals, festivals, or other recurring conditions.



5.4 Bivariate Correlations

The correlation between real egg prices and maize prices was weak and statistically insignificant (r = .105, p = .193). The correlation between egg prices and soybean-meal prices was also weak, although statistically significant at the 5% level (r = .170, p = .033). The relationship between egg prices and diesel prices was close to zero and statistically insignificant (r = -.038, p = .639).

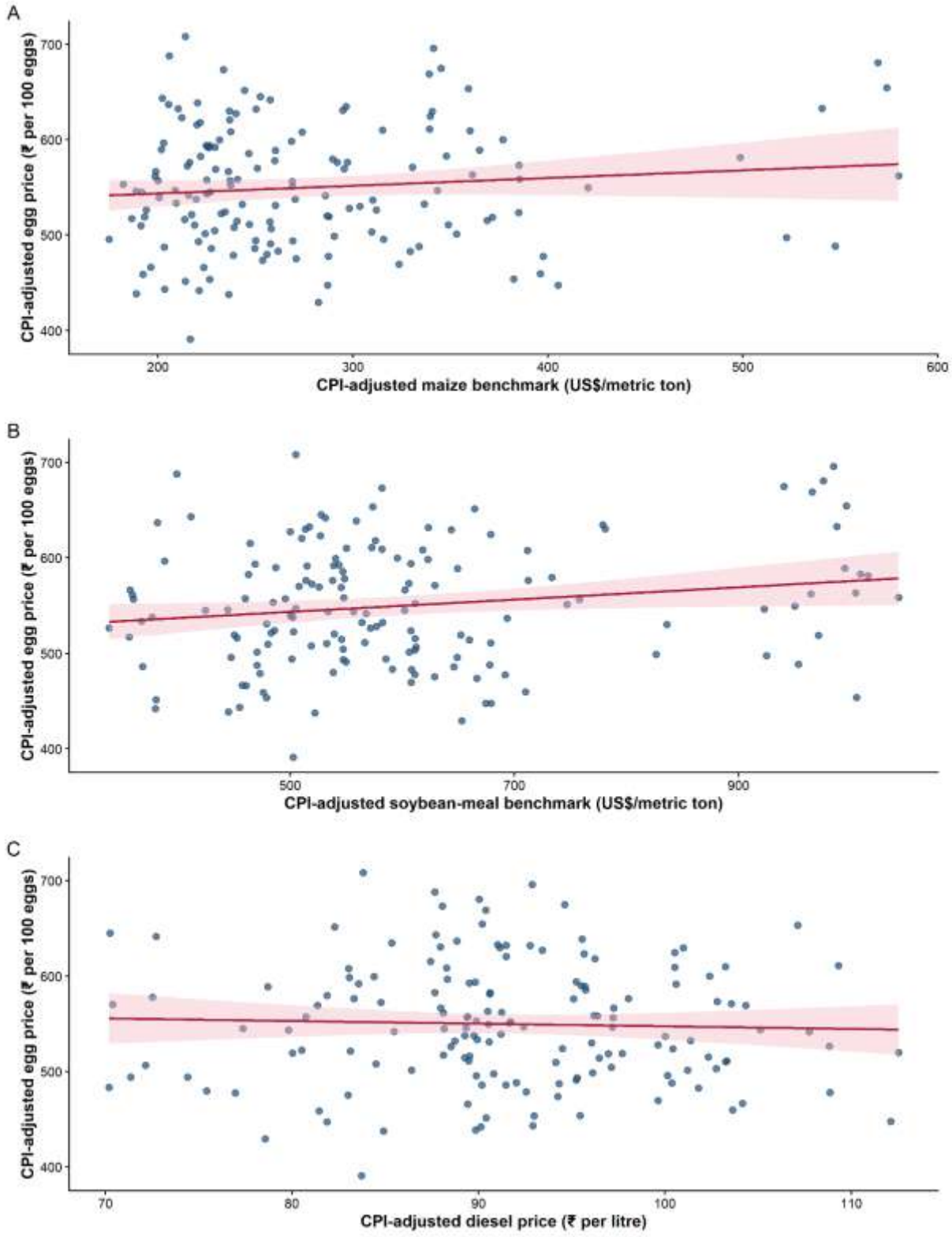
The strongest correlation was between maize and soybean meal (r = .794, p < .001). This indicates that multicollinearity requires attention in the regression analysis, although the final model's VIF values later show that it does not reach a severe level after the full set of covariates and month effects are included.

Table 3. Pearson correlations among CPI-adjusted monthly price variables

Variable	1	2	3	4
1. Producer egg price	-			
2. Maize benchmark	.105 (.193)	-		
3. Soybean-meal benchmark	.170 (.033)	.794 (<.001)	-	
4. Diesel price	-.038 (.639)	.291 (<.001)	.125 (.121)	-

Note. Values are Pearson correlation coefficients; two-sided p-values are in parentheses. N = 156.

The correlations show that no explanatory variable had a strong contemporaneous bivariate relationship with real producer egg prices. This supports the use of multivariable regression, in which the relationship between an input-price variable and egg prices can be assessed while controlling for other feed costs, diesel prices, trend, COVID-period disruption, and seasonality.



6. REGRESSION RESULTS

6.1 Nested Model Comparison

Table 4 presents the six nested OLS models. Models 1-5 included progressively more explanatory variables but had low explanatory power. The final model, which added calendar-month fixed effects, performed substantially better than all earlier specifications.

Model 1 included only the CPI-adjusted maize benchmark. Maize had a positive coefficient, but the estimate was small and statistically insignificant (B = 0.081, p = .193). The model explained only 1.1% of the variation in real producer egg prices.

Model 2 added soybean meal. The model's R-squared rose to .032, but the overall model was only marginally significant at the 10% level. Soybean meal had a positive coefficient and was marginally significant (B = 0.089, p = .073), whereas maize became negative and remained insignificant.

Models 3 and 4 added diesel and the COVID indicator, respectively, but produced only negligible increases in explanatory power. Model 5 added the linear trend. Its explanatory power remained limited (R-squared = .046), although soybean meal became statistically significant in that specification (B = 0.149, p = .037).

The addition of month fixed effects in Model 6 changed the results substantially. The final model explained 63.8% of the variation in real producer egg prices, compared with 4.6% in Model 5. Adjusted R-squared increased from .014 to .596, indicating that the improvement was not solely due to the addition of more regressors. The overall Model 6 F-test was statistically significant, F(16, 139) = 15.31, p < .001.

Table 4. Nested OLS models predicting CPI-adjusted producer egg prices

Model	Variables included	R^2	Adjusted R^2	F statistic	Overall p
1	Maize	.011	.005	F(1,154) = 1.71	.193
2	Maize, soybean meal	.032	.019	F(2,153) = 2.49	.086
3	Maize, soybean meal, diesel	.034	.015	F(3,152) = 1.77	.156
4	Model 3 + COVID	.036	.010	F(4,151) = 1.39	.239
5	Model 4 + trend	.046	.014	F(5,150) = 1.44	.212
6	Model 5 + month fixed effects	.638	.596	F(16,139) = 15.31	< .001

Note. N = 156. January is the omitted reference month in Model 6. Maize and soybean meal are CPI-adjusted global US$/metric-ton benchmark prices.

6.2 Final Model Results

After controlling for trend, COVID, and calendar-month effects, soybean meal was the only non-seasonal price variable with a statistically significant association with real producer egg prices. Its coefficient was positive (B = 0.097, 95% CI [0.007, 0.187], p = .035). Holding the other model variables constant, a one-unit increase in the CPI-adjusted soybean-meal benchmark was associated with an estimated ₹0.097 increase in producer egg prices per 100 eggs.

The maize coefficient was positive but statistically insignificant (B = 0.051, p = .470). The diesel coefficient was negative and statistically insignificant (B = -0.791, p = .155). The COVID coefficient was positive but statistically insignificant (B = 11.210, p = .267), and the time-trend coefficient was small and statistically insignificant (B = 0.158, p = .261).

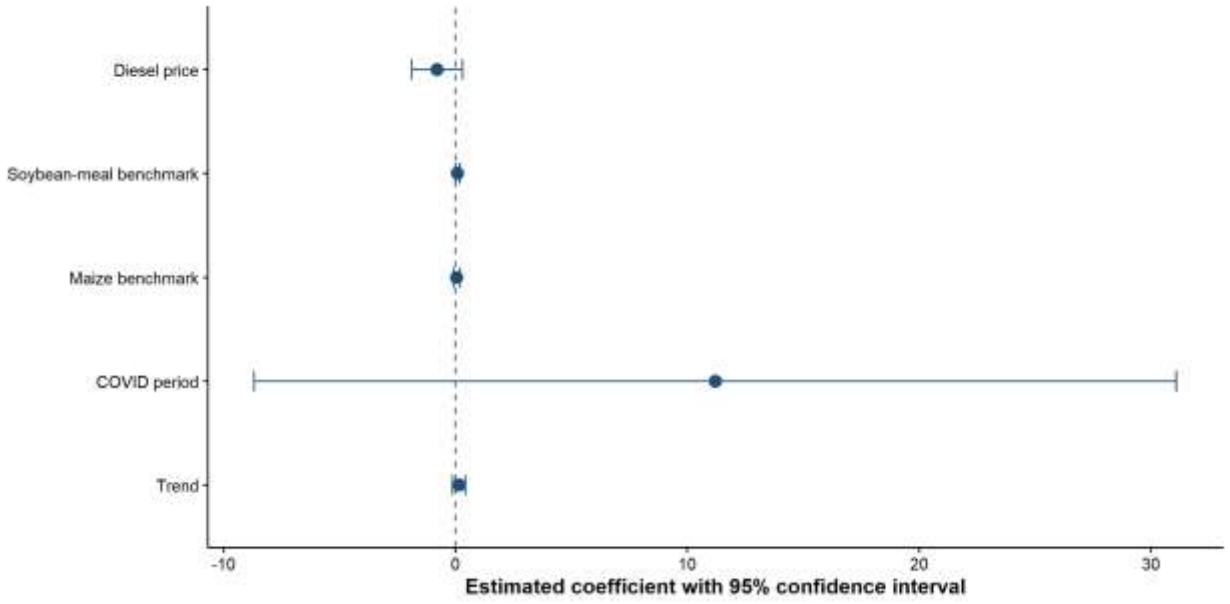
Table 5. Final OLS model predicting CPI-adjusted producer egg prices

Predictor	B	SE	t	p	95% CI
Intercept	585.945	38.927	15.05	< .001	[509.064, 662.825]
Trend	0.158	0.140	1.13	.261	[-0.118, 0.434]
COVID period	11.210	10.059	1.11	.267	[-8.656, 31.077]
February - January	-55.234	15.839	-3.49	< .001	[-86.517, -23.952]
March - January	-112.882	15.860	-7.12	< .001	[-144.206, -81.559]
April - January	-138.818	15.876	-8.74	< .001	[-170.173, -107.464]
May - January	-85.820	15.899	-5.40	< .001	[-117.221, -54.418]
June - January	-25.983	15.899	-1.63	.104	[-57.383, 5.418]
July - January	-51.209	15.904	-3.22	.002	[-82.618, -19.799]

Explaining Indian Egg Price Dynamics: Seasonal Patterns, Feed Costs, and Diesel Prices, 2013–2025

Predictor	B	SE	t	p	95% CI
August - January	-88.102	15.950	-5.52	< .001	[-119.604, -56.600]
September - January	-53.583	15.977	-3.35	.001	[-85.138, -22.029]
October - January	-36.497	15.929	-2.29	.023	[-67.957, -5.038]
November - January	15.152	15.926	0.95	.343	[-16.301, 46.605]
December - January	33.083	15.924	2.08	.040	[1.634, 64.532]
Maize benchmark	0.051	0.071	0.72	.470	[-0.088, 0.191]
Soybean-meal benchmark	0.097	0.046	2.13	.035	[0.007, 0.187]
Diesel price	-0.791	0.553	-1.43	.155	[-1.883, 0.301]

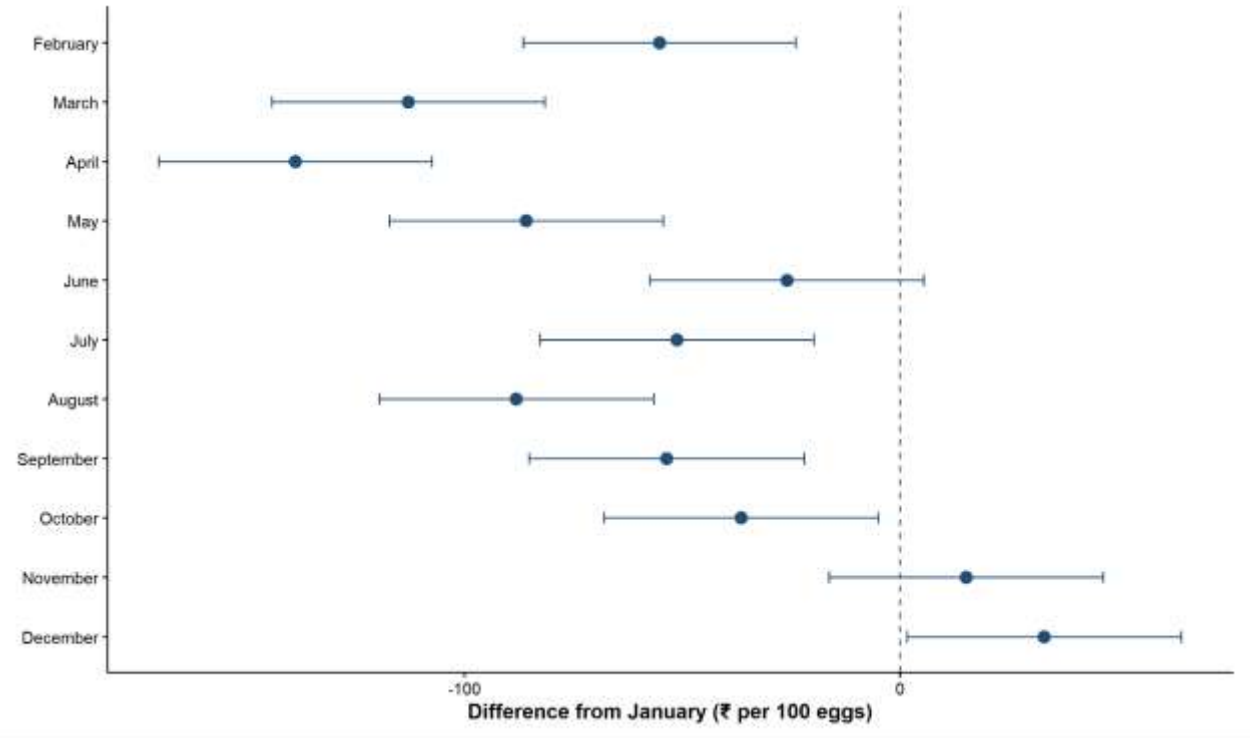
Note. Dependent variable: CPI-adjusted producer egg price in ₹ per 100 eggs. N = 156. Model R^2 = .638; adjusted R^2 = .596. January is the reference month. Coefficients are conditional associations and should not be interpreted as causal effects.



6.3 Seasonal Effects

The strongest results in Model 6 were the calendar-month coefficients. Relative to January, producer egg prices were significantly lower in February, March, April, May, July, August, September, and October. The largest estimated reduction occurred in April, when prices were ₹138.82 per 100 eggs lower than in January, holding the remaining variables constant.

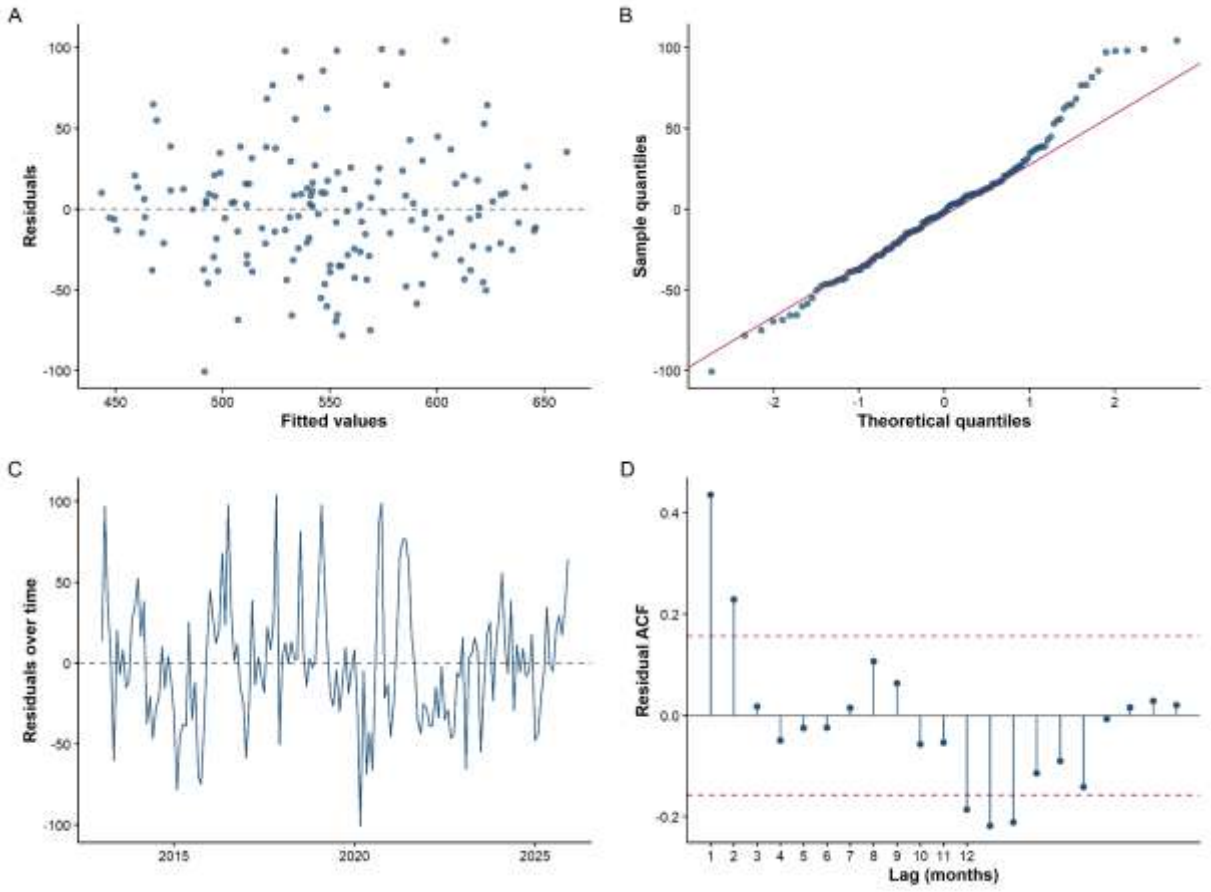
March prices were estimated to be ₹112.88 lower than January prices, while May and August prices were lower by ₹85.82 and ₹88.10, respectively. June and November were not statistically different from January. December was the only month with a statistically significant positive coefficient, indicating that producer egg prices were approximately ₹33.08 per 100 eggs higher than in January. These findings demonstrate that recurring seasonality explains a substantial share of monthly producer egg-price variation.



6.4 Diagnostic Results

The final model did not show serious multicollinearity. VIF values were 1.79 for maize, 2.36 for soybean meal, 1.49 for diesel, 1.95 for trend, and 1.08 for the COVID indicator. Cook's distance diagnostics also indicated no highly influential observations; the maximum Cook's distance was 0.0856, well below the commonly used threshold of 1.0.

The Shapiro-Wilk test indicated a modest departure from exact residual normality ($W = .977$, $p = .012$). The Q-Q plot nevertheless showed that most observations followed the theoretical normal line reasonably closely, with the principal deviation in the upper tail. The residuals-versus-fitted plot showed broadly random scatter without strong curvature or a clear funnel-shaped pattern. The residual ACF plot did not indicate a material autocorrelation pattern, and the reported diagnostic procedures found no statistically significant autocorrelation or heteroskedasticity.



6.5 Stationarity and Lagged Specifications

ADF tests indicated mixed orders of integration among the price series. Real producer egg prices and the maize benchmark were stationary in levels. Soybean meal and diesel were not stationary in levels but became stationary after first differencing.

Table 6. Augmented Dickey-Fuller test results

Variable	Level ADF statistic	Level p	AIC-selected lags	Conclusion
Real producer egg price	-4.189	.00076	13	Stationary, I(0)
CPI-adjusted maize benchmark	-3.273	.01798	3	Stationary, I(0)
CPI-adjusted soybean-meal benchmark	-2.224	.20090	1	Non-stationary, I(1)
CPI-adjusted diesel price	-1.977	.28756	6	Non-stationary, I(1)
Change in soybean-meal benchmark	-8.104	.00002	-	Stationary
Change in diesel price	-4.877	.00004	-	Stationary

Note. ADF tests included an intercept and deterministic linear trend. Lag length was selected using the Akaike Information Criterion.

The mixed integration order means that the level-regression results should be interpreted cautiously. In particular, the non-stationarity of soybean meal and diesel prices creates a risk of spurious association in a simple level regression. This issue is addressed further in the limitations section.

Finally, Models 7-10 assessed one-month and two-month lagged feed-price specifications using the same broad modelling strategy. These lagged alternatives produced slightly weaker model fit than the contemporaneous Model 6 specification. The contemporaneous model was therefore retained as the preferred model.

7. DISCUSSION

7.1 Principal Findings

This study examined the factors associated with monthly CPI-adjusted producer egg prices in India between January 2013 and December 2025. The central finding is that recurring seasonality was the strongest observed determinant of producer egg-price variation. Once month fixed effects were included, the model explained 63.8% of the variation in real producer egg prices, compared with only 4.6% in the preceding model without month effects.

The final model showed especially large negative price differences relative to January in March, April, May, and August. April had the largest estimated seasonal effect: holding the other variables constant, real producer egg prices were approximately ₹138.82 per 100 eggs lower than in January. December prices were approximately ₹33.08 higher than January prices. This is consistent with the pattern identified by Pradheeshwaran (2025), who found prices lowest in April and highest in December across a broad set of Indian markets.

The result should not be interpreted as evidence that one single factor causes seasonal price changes. Month fixed effects capture all recurring calendar-month influences that are not directly measured in the model, including possible weather conditions, seasonal demand, supply and market arrivals, institutional demand, and production cycles.

7.2 Feed Prices and Producer Egg Prices

Soybean meal was the only non-seasonal price variable that remained statistically significant in the final model. Its positive coefficient indicates that higher CPI-adjusted soybean-meal benchmark prices were associated with higher producer egg prices, even after accounting for seasonality and the other controls. This result is economically plausible because soybean meal is a major protein ingredient in poultry feed.

By contrast, maize was not statistically significant in the final model. This does not mean that maize is unimportant to poultry production. Previous Indian research has found evidence of price transmission between maize and poultry markets (Ajjan et al., 2012). Instead, the result means that the study does not identify an independent contemporaneous association between the World Bank maize benchmark and producer egg prices once soybean meal, diesel, trend, COVID, and seasonality are controlled for.

Several explanations are possible. The two feed-price series were strongly correlated; the measures are global US$/metric-ton benchmarks rather than domestic farm purchase prices; and producers may respond to feed-price changes with lags or through adjustments in feed formulation, inventory, and margins. The soybean-meal result is therefore an estimated conditional association, not a causal effect.

7.3 Diesel, COVID-19, and Trend

Diesel prices were not statistically significant in the final model. The negative estimated coefficient should not be interpreted as evidence that higher diesel prices reduce egg prices because its confidence interval included zero. The result may reflect the indirect nature of diesel costs and the fact that the national diesel proxy cannot capture every regional freight market or farm-level transport arrangement.

The COVID-period indicator was also statistically insignificant. This does not imply that COVID-19 had no effect on India's poultry sector. Existing research documents major disruptions to poultry demand, labour, transport, feed access, and marketing during the pandemic (Kolluri et al., 2021). Rather, the result indicates that the broad March 2020-December 2021 dummy did not explain additional average monthly variation after the model controlled for feed-price benchmarks, trend, and month effects.

The insignificant time trend suggests that no remaining linear increase or decrease in CPI-adjusted producer egg prices was detectable after the included input-price variables and seasonal effects were accounted for.

7.4 Relationship to Previous Research

The study supports and extends the Indian egg-price literature. Previous work has established that egg markets in India are spatially connected, though not perfectly uniform (Saran & Gangwar, 2008; Sendhil et al., 2013). It also aligns with seasonal studies, although the precise timing of peak months varies across datasets and locations. Such variation is expected because local demand, supply, weather, and transportation conditions differ across India.

The present analysis contributes by combining several potential determinants within one nested regression framework. Earlier studies often focus primarily on market integration, decomposition of price trends, or forecasting. The results demonstrate that the apparent importance of feed and fuel variables changes once seasonality is explicitly controlled.

7.5 Practical Implications

The findings have practical implications for producers, feed suppliers, traders, and policymakers. Producers may benefit from anticipating relatively weak price conditions during spring months, especially around March and April, and stronger

conditions during late-year months. This does not guarantee future prices, but it provides a useful baseline for production, working-capital, and feed-procurement planning.

Soybean-meal market conditions may also warrant closer monitoring. Since soybean meal remained positively associated with producer egg prices after controlling for seasonality, sharp changes in protein-feed costs may affect producer margins or pricing pressure. Policies designed to improve market stability should consider seasonal forecasting, feed availability, regional supply chains, and market information together rather than focusing only on diesel prices or isolated crisis periods.

7.6 Interpretation Boundaries

The final model identifies strong statistical associations, particularly for seasonality, but it does not establish causation. The month fixed effects capture recurring differences without identifying their exact causes. Similarly, the soybean-meal result should not be interpreted as proof that an increase in the global benchmark directly causes a corresponding increase in Indian producer egg prices.

The model also does not include several potentially important factors, such as weather, disease outbreaks, poultry inventories, domestic feed prices, exchange rates, feed formulation, regional demand, festival timing, school-meal demand, and state-level transport conditions. The following section discusses these limitations in detail.

8. LIMITATIONS

This study provides evidence on the factors associated with monthly producer egg prices in India, but its findings should be interpreted within several important limitations.

First, the study is observational and cannot establish causal relationships. The regression estimates show conditional associations between producer egg prices and the included explanatory variables. For example, the positive soybean-meal coefficient does not prove that a rise in soybean-meal prices directly causes a rise in producer egg prices. Unobserved factors may influence both variables at the same time.

Second, the dependent variable is a national monthly average constructed from NECC city-level price quotations. The set of reporting cities changed over the 2013-2025 period, and each available city-day quotation was given equal weight. The series is not weighted by city population, egg production, market volume, or transaction volume. It is therefore a broad indicator of quoted producer-price movements, not a perfectly representative national transaction price.

Third, NECC prices are quoted market reference prices rather than verified transaction-level farm-gate prices for every producer in India. Individual producers may receive different prices because of farm size, contract arrangements, egg quality, location, transport access, buyer relationships, and local supply conditions.

Fourth, the maize and soybean-meal variables are global World Bank benchmark series measured in US dollars per metric ton. They are not domestic Indian feed prices in rupees. Their relationship with the actual costs faced by Indian poultry farms may be affected by exchange-rate movements, import and trade policy, domestic harvest conditions, feed-mill pricing, procurement contracts, transport costs, and substitution between ingredients. Applying Indian CPI rebasing to US-dollar commodity benchmarks does not convert them into domestic real rupee prices.

Fifth, the model omits potentially relevant determinants, including weather, temperature, rainfall, humidity, disease outbreaks, poultry mortality, flock inventories, laying-hen productivity, domestic feed prices, exchange rates, electricity and labour costs, festival timing, school-meal demand, consumer incomes, and regional transport conditions. Some may be partly captured by month effects, but they are not measured directly.

Sixth, monthly aggregation improves comparability across data sources but conceals short-run price changes. Egg prices and diesel prices were originally observed daily, yet the final analysis uses monthly averages. Sudden shocks, short-duration supply disruptions, or rapid feed-price pass-through may therefore be smoothed out.

Seventh, the ADF results indicate mixed orders of integration. Real producer egg prices and maize prices were stationary in levels, whereas soybean meal and diesel prices became stationary only after first differencing. This creates a risk of spurious relationships in a level-based OLS regression. The study did not estimate a formal cointegration model, autoregressive distributed lag model, or first-difference robustness specification.

Eighth, the residual-normality test indicated a mild departure from exact normality. The Shapiro-Wilk result was statistically significant ($W = .977$, $p = .012$), although the Q-Q plot suggested that the deviation was concentrated mainly in the upper tail. With 156 observations, OLS estimation is generally reasonably robust to modest non-normality, but the paper does not claim perfect residual normality.

Ninth, the COVID variable is necessarily a simplified representation of a complex event. It treats every month from March 2020 through December 2021 as part of one common disruption period, although early misinformation, lockdown restrictions, transport disruption, institutional demand, and reopening may have affected egg prices in different directions.

Finally, month fixed effects capture seasonality effectively but do not explain it. Future research should combine price data with direct measures of temperature, rainfall, poultry production, disease, feed availability, and consumer demand. It should also report exact formal test statistics for heteroskedasticity and serial correlation and consider dynamic or panel-data methods.

9. CONCLUSION

This study examined the primary determinants of CPI-adjusted monthly producer egg prices in India from January 2013 through December 2025. Using 156 monthly observations, the analysis considered international maize and soybean-meal price benchmarks, domestic diesel prices, a COVID-period indicator, a linear trend, and calendar-month fixed effects.

The central finding is that recurring seasonality was the strongest observed determinant of producer egg-price variation. Before month effects were added, the regression models explained less than 5% of the variation in real producer egg prices. Once month fixed effects were included, the final model explained approximately 63.8% of monthly variation, with an adjusted R-squared of 59.6%. Producer egg prices were significantly lower than January prices in most months between February and October, particularly in March and April. December was the only month with a statistically significant positive difference from January.

Soybean meal was the only non-seasonal input-price variable that remained statistically significant in the final model. Higher CPI-adjusted global soybean-meal benchmark prices were associated with higher producer egg prices after controlling for seasonality, maize, diesel, COVID, and trend. In contrast, the study found no statistically significant independent contemporaneous association for maize prices, diesel prices, the COVID-period dummy, or the linear trend.

The results suggest that producer egg prices in India should not be explained primarily through visible input-price changes alone. Feed costs matter, particularly soybean meal, but predictable annual seasonal conditions appear to explain a much larger share of variation in monthly producer egg prices. Producers, feed suppliers, and policymakers may therefore benefit from monitoring seasonal price patterns alongside feed-market conditions rather than reacting only to isolated commodity or fuel-price movements.

At the same time, the results should not be interpreted as causal estimates. The analysis uses national averages, global feed-price benchmarks rather than domestic farm-level feed prices, and an observational time-series design. Future research could combine state- or city-level producer prices with domestic feed-price data, weather measures, poultry inventory information, disease-outbreak indicators, exchange rates, and detailed demand proxies. Within these limits, the study provides evidence that seasonality is the dominant observed correlate of monthly producer egg-price variation in India, while soybean meal is the most consistently relevant feed-price benchmark.

Appendix A. Data Construction and Variable Definitions

Producer egg prices were based on daily NECC city-level quotations and aggregated as an arithmetic mean of all available city-day observations in each month. The reporting-city set was not constant over time. Diesel was derived by averaging daily retail HSD prices within each of Delhi, Mumbai, Kolkata, and Chennai, then calculating an unweighted mean of the four city-month averages.

The COVID dummy was coded 1 from March 2020 through December 2021 and 0 otherwise. The trend variable ran from 1 in January 2013 to 156 in December 2025. January was the reference category for the eleven month indicators. Price variables were rebased with CPI-adjusted price_t = nominal price_t × (CPI_December 2025 / CPI_t).

Appendix B. Supplementary Model and Diagnostic Summary

Item	Result
Preferred specification	Contemporaneous Model 6 with month fixed effects
Lagged models	One-month and two-month feed-price specifications had slightly weaker fit
Maximum Cook's distance	0.0856
VIF range in final model	1.00-2.36
Shapiro-Wilk residual test	W = .977, p = .012
Residual plots	No strong curvature or clear funnel pattern reported
Residual autocorrelation and heteroskedasticity	No statistically significant pattern reported

Appendix C. Figure Production Checklist

- Figure 1: four-panel monthly time-series plot with separate y-axes and COVID boundary lines.
- Figure 2: monthly mean producer egg-price profile with 95% confidence intervals.
- Figure 3: three scatterplots with OLS fitted line and 95% confidence band.
- Figure 4: non-seasonal Model 6 coefficient plot with 95% confidence intervals.
- Figure 5: calendar-month coefficient plot, with January as reference and a zero line.
- Figure 6: final-model residual diagnostics: fitted, Q-Q, time, and ACF panels.

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