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RESEARCH ARTICLE

Incomplete pass-through and variability in domestic prices: empirical evidence from the Indian wheat market

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Abstract

The study estimates the contribution of changes in world prices, exchange rates, and trade policies in explaining the variability of domestic prices under the scenario of incomplete transmission of changes and a counterfactual scenario of complete pass-through. We utilize data from the Indian wheat market for the period 2006–09 and 2017–20. The findings reveal an improvement in the pass-through of changes from the landed price to domestic markets. The price transmission elasticity increased from 50% in 2006/07–2008/09 to 67% during 2017/18–2019/20. The policy response to rising (declining) global prices of decreasing (increasing) import tariffs had a significant effect on prices. The variation in exchange rate offsets the impact of declining or rising global prices on domestic prices.

Keywords: Ag-trade; agricultural policies; exchange rates; infrastructure; price transmission; world prices

JEL Codes: D52; F15; P22; Q11

Introduction

During 2007–08 and 2022–23, the world food grain market experienced periods of relatively high and low prices. Agricultural commodity price peaks were especially significant in 2008, 2011, and 2022, with the International Monetary Fund's monthly global food price index reaching a record high in April 2022 (Figure 1). In recent years, there has been a notable increase in global grain prices. The outbreak of COVID-19 and Russia's invasion of Ukraine in early 2022 have heightened global economic uncertainty (Martin and Minot 2022). Amidst fluctuations in global food prices, a crucial question arises: how do the changes in global prices affect the prices faced by domestic producers and consumers? The changes in global prices are responsible for changes in demand and supply, as well as determine the effects on households. As food accounts for significant shares of household consumption baskets in developing countries, the changes in prices have a disproportionate impact on low-income families. Additionally, an increase in food

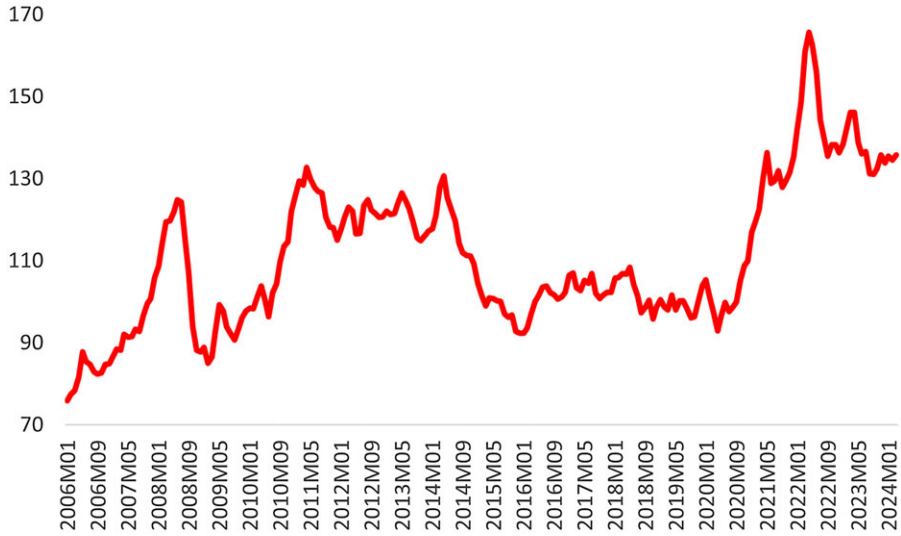

Figure 1. World Food Price Index (2016 = 100).

grain prices would negatively impact global food security and could increase the number of undernourished people (FAO 2022). The transmission of changes in world prices plays a crucial role in determining the effects of price shocks on domestic market prices.

A large body of research has focused on factors determining the extent of global price transmission to domestic markets (Olipra 2020). Several factors impact price transmission between the global and domestic markets. First, trade policy instruments such as high tariffs, variable tariffs, non-tariff barriers (licenses, certificates), state trading, tariff-rate quota (TRQs), technical barriers to trade, and complete bans on trade can impede the transmission of changes in world price and exchange rate to the domestic market.[1] Second, macroeconomic policy decisions may hinder the transmission of fluctuations in exchange rates to domestic prices (Liefert and Persaud 2009). Empirical evidence shows that fluctuations in exchange rates result in less than proportional increases in the prices of traded products, and a significant portion of the price reaction takes place in a considerable amount of time lag.[2]

Third, market competition can affect price transmission. For instance, a small group of traders could manipulate the price transmission of changes in border prices to domestic prices.[3] Fourth, a weak infrastructure, including both physical and institutional – a common feature in many developing countries – could lead to higher transaction costs, insulating domestic markets and thus hindering the smooth flow of crucial market information from border areas to the interior regions (Fackler and Goodwin 2001; Barrett 2001; Barrett and Li 2002).[4] Fifth, market expectations can impact the transmission of prices. During periods of rising international prices and the anticipation of further

[1]See Swift 2004; Conforti 2004; Minot 2011; Ghoshray 2011; Arnade, Cooke, and Gale 2017.

[2]See Engel 1999; Parsley and Wei 2001; Goldberg and Campa 2006; Dawe 2008; Dornbusch 1987.

[3]For example, Goodwin and Schroeder 1991; Morisset 1998; Azzam 1999; Goodwin and Holt 1999; Wohlgenant 1999; McCorriston, Morgan, and Reyner 2001; Ghoshray 2007; Minot 2011; McLaren 2015.

[4]Baquedano et al. (2011) observed that interior parts of Mali face more challenges in terms of infrastructure and price transmission.

increases, farmers, traders, and households may choose to stockpile supplies. This could result in a reduction in domestic supply and subsequently lead to a rise in domestic prices. The above literature fails to address the contribution of the above factors to domestic price variability. In other words, previous studies have not quantified the effect of changes in trade prices, exchange rates, and trade policies on domestic price variability. Although Tripathi's (2013) study decomposed the variability in wheat, rice, edible oils, and sugar prices for the 2001–04 period, the study failed to quantify the contribution of the factors causing incomplete pass-through to domestic price variability. Additionally, Tripathi (2013) used data from the early years of India's 1990 economic reforms. However, a decade of reforms such as reducing import tariffs, deregulating markets, and lowering taxes has led to significant economic growth, income, investment in infrastructure[5], privatization of state-owned enterprises, and other market reforms.

Therefore, the objective of this study is twofold. First, to investigate the extent to which variation in domestic food prices is due to fluctuations in the exchange rate, world prices, and sector-specific trade policies in the Indian wheat market. Second, to compute the relative variability in domestic prices under the counterfactual scenario of complete transmission of changes in world prices and exchange rates. The study uses the theory of spatial market equilibrium and a decomposition model framework by Liefert (2011). Unlike Leifert's (2011) study where a country has market power in a good, its decision to import would raise world demand sufficiently to increase world price to a certain extent. In this study, India is a small player in the world wheat market. India produced wheat mainly for the domestic market. India exported only 2.2% of its production volume in 2000–2016. Thereby, India's share in world wheat exports in 2000–16 amounted to a negligible 1.28%. Similarly, in the case of imports over the past two and a half decades, barring 4–5 occasions, India imported wheat, albeit in very small quantities, owing to fluctuations in domestic demand and supply. The data for the study include 2006–07 to 2008–09 and 2017–18 to 2019–20, periods where India is considered a net importer of wheat. The period corresponds to substantial movements in trade prices, exchange rates, and trade policy that affected domestic wheat prices.

The current study adds to the literature in several ways. First, it complements and expands Tripathi's (2013) work by analyzing the contribution of trade prices and exchange rates to variability in domestic prices under an importable scenario. India's wheat trade status has varied over the period.[6] Thus, one can anticipate a variation in price transmission elasticity and impact on domestic prices due to changes in trade prices and exchange rates. Second, by analyzing the price transmission elasticity in two distinct periods, 2006–07 to 2008–09 and 2017–18 to 2019–20, we capture improvement in agricultural infrastructure that can facilitate the transmission of changes in trade prices and exchange rates to domestic producers. Finally, the study uses recent data covering the global economic uncertainty caused by the outbreak of COVID-19.

[5]Major government initiatives include the Agricultural Marketing Infrastructure (AMI) Scheme, Agriculture Infrastructure Fund (AIF) Scheme, Pradhan Mantri Kisan Sampada Yojana, National Agriculture Market, establishment of Agri Export Zones (AEZs), the Agricultural Produce Marketing (Development and Regulation) Act of 2003 and 2017, the Mahatma Gandhi National Rural Employment Guarantee Scheme, and the Pradhan Mantri Gram Sadak Yojana (PMGSY).

[6]For instance, during 2000–05, India was a net exporter (NE); in 2006–10, it became a net importer (NI); in 2011–15, it was a net exporter (NE); in 2016–19, it was a net importer (NI); and again, in 2020–23, it was a net exporter (NE).

India's wheat market

In India, wheat holds a significant position as a main staple and principal food grain crop. India cultivates wheat across a vast area of 26.34 million hectares, resulting in a substantial production of 109.59 million metric tons (MMT) (FAO 2021). India plays a significant role in the global wheat market, being the second-largest producer of wheat worldwide. It contributes more than 13% to global wheat production. Through the implementation of yield-enhancing green revolution technology and market interventions, there has been a significant increase in wheat production in India on a sustained basis. This has been achieved by carefully balancing the interests of both producers and consumers. Four broad policy instruments have played a significant role, including producer price support, trade policies, input subsidies, and food distribution subsidies (OECD 2014).

Wheat market intervention by the government consists of minimum support price and procurement, buffer stock maintenance, the public distribution system, and open market operations. In addition, the wheat trade is subject to several restrictions, including a license and permit system, multi-tiered tariff structure, quota, and trade prohibition. Wheat is subject to state trading requirements in India (WTO 2015). However, the enforcement mechanism is contingent upon domestic supplies and prices. The primary government agency responsible for implementing food policy is the Food Corporation of India (FCI). It procures grain from farmers and distributes it to consumers, working in collaboration with state agencies. Additionally, the FCI manages the government's "central pool" of stocks through transactions in both international and domestic markets.

The FCI conducts open-ended procurement of wheat at a pre-announced *minimum support price* (MSP).[7] The pre-announced MSP, defended by public procurement, places an effective floor on domestic prices, especially when the corresponding market prices fall. A recent study (Tripathi 2024) found that implementing a price floor policy reduces the probability of significant price declines by truncating the lower end of the price distribution and has a price-enhancing effect. The implementation of a price floor policy could potentially lead to a situation where domestic prices exhibit no correlation with the international market beyond a specific threshold or to a nonlinear relationship where the domestic level quickly absorbs rise in global prices and falls in international prices are passed on at a comparatively slower pace (Ghoshray 2011).

In addition to the above policies, there are also restrictive trade policies that use a mix of tariffs and non-tariff barriers to keep prices and supplies stable in the domestic market. Despite significant liberalization, wheat trade policy in India remains complex. Wheat trade is managed through a combination of instruments such as permit and licensing requirements, quotas, taxes, state trading requirements, and tariff structure with multiple rates. Whether these instruments are enforced or not depends on domestic supply and prices. The role of state trading enterprises was emphasized as a canalizing agency for wheat trade. In this case, the government establishes a quota, determines the quantity of a commodity to be exported or imported, and insulates domestic prices from fluctuations in trade prices and exchange rates (see Ackerman and Dixit 1999).

The government adjusted its trade policy instruments from time to time, considering factors such as domestic production, price dynamics, and the global landscape. Since 1998, there has been a recurring pattern of accumulating large stocks of wheat, exporting them, depleting the stocks, and then importing large quantities again (Chand 2009). In the case of wheat, Tripathi (2013) showed that, under an exportable scenario, during the period

[7]The MSP levels for wheat are recommended by the Commission of Agricultural Costs and Prices and are declared prior to grain production for fair-to-average quality grain. Farmers are paid directly by the FCI at the primary marketplaces where they offer their agricultural produce.

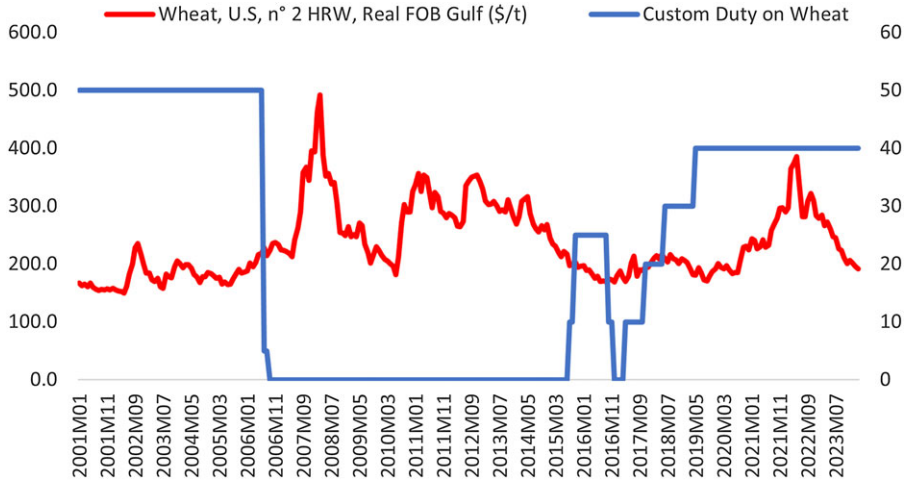

Figure 2. Trend in international wheat price and India's basic custom duty on wheat, 2001M01–2024M03 (prices in real terms).

2001–2004, poor transmission of changes (with a transmission elasticity of 30%) in trade prices and exchange rates on domestic prices has precluded much of the potential price change. The trade policy response to low world prices, which involved raising export subsidies, has largely neutralized the impact of low world prices on Indian wheat exports.

In 2005–06, the real-world price of wheat started picking up (from 180.71 $/t) and reached a peak in 2007–08 (337.11$/t). High world prices have made wheat imports less attractive. Wheat imports fell from 6 MMT in 2006–07 to 1.8 MMT in 2007–08. Additionally, high world prices forced India to reduce import duty from 50% in 2006–07 to zero in 2007–08 (Figure 2). Figure 2 illustrates the trend in the real-world price of wheat.[8] By December 2016, the world price had dropped more than 50% from its peak in November 2012. However, after reaching their lowest level (i.e., 175.7 $/t in 2016–17[9]), prices started picking up slowly and hovered between 185.5 $/t and 206.6 $/t during 2017–18 and 2019–20 but remained much lower than the level reached in 2012–13 (i.e., 318.2 $/t). As a result, imports started picking up, and within two years, beginning in 2015–16, India imported more than 6 MMT of wheat. A low level of world prices forced the country to impose an import duty starting in August 2015, varying from time to time (Figure 2).

The heatwaves in major wheat-producing states in India during the 2014–15 crop season resulted in a decline in wheat production by more than 9 MMT over the previous year. Consequently, in 2016, wheat procurement witnessed a significant decrease, and wheat stock with public agencies was reduced to 30 MMT by July 2016. Along with this, the falling world prices (world wheat prices dropped by more than 50% by December 2016 from their peak in November 2012) made wheat importation an attractive proposition. For three years, starting in 2015–16, India imported about 8 MMT of wheat. Low world prices in 2016–17 forced India to impose a tariff on wheat imports (Figure 3). To prevent cheap imports, the government increased import duty to 28.33% in 2018–19 and further to

[8]The world wheat price refers to US Hard Red Winter (HRW) No. 2, FOB US Gulf price. Real prices are derived by dividing the nominal prices by Consumer Price Index, for the USA, prices, all items, with base 2010 = 100.

[9]Prices corresponds to annual average for marketing year, that is, from April to March.

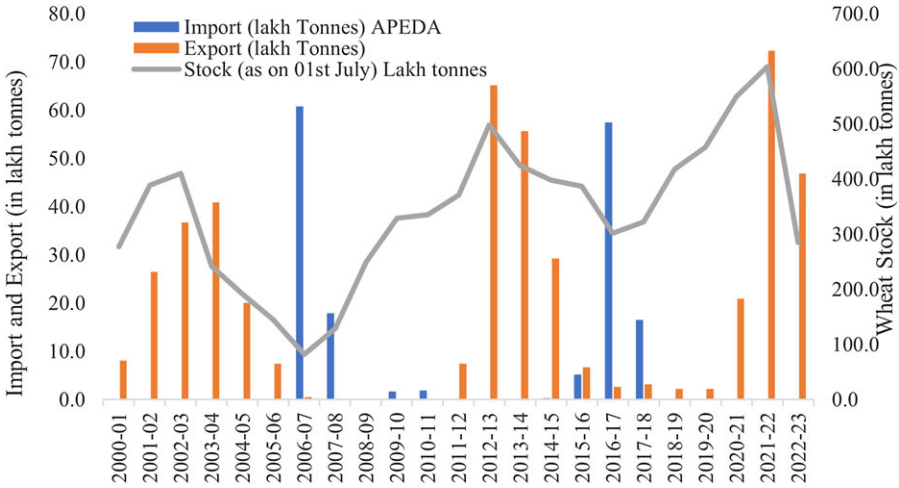

Figure 3. Trend in wheat export, import, and stock at the central pool from 2000–01 to 2022–23.

39.17% in the subsequent year. As a result, wheat imports dropped to 1.6 MMT in 2018–19, down from 5.7 MMT in 2017–18.

A relatively low but stable trajectory of global wheat prices from 2017 to mid-2020 made Indian wheat uncompetitive in the global market. Additionally, the increase in domestic production[10] resulted in the accumulation of wheat stocks in the country, much more than the buffer stock norms. The wheat stock in the central pool reached 60.36 MMT on July 01, 2021, much above the stocking norm of 27.6 MMT. Following a substantial rise in the global prices of wheat after mid-2020, Indian wheat regained its competitiveness. As a result, between mid-2020 and May 2022, India shipped around 12 MMT of wheat before implementing a ban on wheat exports (Figure 3).

Literature review

Many studies have investigated market integration and transmission of price signals by deploying various analytical techniques. These studies highlight several factors that limit the transmission of price signals. Import tariffs, TRQs, export subsidies or taxes, and intervention mechanisms are examples of agricultural policy instruments that can influence domestic markets in addition to exchange rate policies. These policies have the potential to disrupt the transmission of world price signals by affecting the domestic market's excess supply and demand schedules (Quiroz and Soto 1993; Rapsomanikis, Hallam, and Conforti 2003; Timmer 2008; Baffes and Gardner 2003; Imai, Gaiha, and Thapa 2008; Keats et al. 2010; Ghoshray 2011; Ianchovichina, Loening, and Wood 2014; and IMF 2011). However, only a small number of studies have formally evaluated the impact of policy interventions on domestic price variability and price transmission. In this study, we present a review of the studies that quantify the effect of policy interventions on price transmission exclusively.

In their study, Rapsomanikis, Hallam, and Conforti (2003) analyzed the spatial price transmission in developing countries in various cash and food crop markets. The study

[10]Wheat production reached a record level of 109.59 MMT in 2020–2021 (marketing year).

suggests that depending on specific agricultural policy instruments, it can either impede or facilitate market integration. In the case of the Rwandan coffee market, they found that the coffee market was disconnected from the global coffee market due to government regulation with predetermined price levels. Additionally, the research offers insight into the Egyptian wheat market, demonstrating that floor price policies did not hinder market integration. However, it did lead to a gradual and uneven response to fluctuations in international prices. In general, regulated markets showed relatively low-price transmission in terms of both degree and speed.

Liefert (2011) decomposed the changes in real agricultural producer prices for the major emerging market economies of Brazil, China, and South Africa. For each country, the authors decomposed the changes in the real producer price for beef, pork, and poultry, as well as one other commodity specific to each country. Findings revealed that the transmission from border/landed prices to domestic producer prices was high. Changes in both world prices and exchange rates would cause a large movement in real domestic prices. The results also showed that incomplete transmission, caused not by policies but rather by market conditions such as weak agricultural market infrastructure, prevented much of the potential fluctuation in producer prices in the domestic country.

Using data from 2003 to 2007 from selected Asian economies, Dawe (2008) analyzed the transmission of increased global cereal prices to domestic prices. The author found that the transmission of international food prices was mostly incomplete. The author argued that the increase in the currency value, compared to the US dollar, offset a significant portion of the global price increases in the local markets. In Asian countries, local policies regarding specific agricultural commodities, particularly rice, are effectively stabilized and protect domestic prices from fluctuations in global prices.

In the Indian context, Sekhar (2012) investigated spatial integration in specific commodity markets in India. The author found that commodity markets, such as gram and edible oils, with no inter-state trade restrictions, were well-integrated. Conversely, rice markets with inter-state movement restrictions lacked national integration. Similarly, Baylis et al. (2014) analyzed the integration between specific wheat and rice markets in India both before and during the export bans. The authors found that the export ban resulted in a separation between the domestic and global markets for both rice and wheat. Furthermore, there was a noticeable absence of market integration between the producing and consuming regions within India. In addition, the findings indicated that the export ban led to a rise in domestic price fluctuations caused by disruptions in domestic supply.

In another study, Elleby et al. (2015) investigated the impact of India's export ban during the global food price crisis on domestic market prices and, subsequently, consumer welfare. The authors found that the export ban did indeed exert a substantial impact on the domestic retail price of rice and wheat. The domestic price of wheat dipped approximately 40% lower than it would have been without the export ban. Tripathi (2013) analyzed the effects of trade prices, the exchange rate, and agricultural trade policies on changes in domestic prices of wheat, rice, sugar, and edible oils. The author found that wheat and rice fell under the exportable hypothesis (covering the 2001–2004 period). The author argued that in most cases, the price transmission elasticity between the domestic price and the landed price was between 30% and 50%. Therefore, it prevented many changes in domestic prices. The trade policy response to low world prices annulled the effect of a rise or fall in world prices on domestic prices. A combination of both government policies and underdeveloped market infrastructure was accountable for the incomplete transmission of changes in trade prices and exchange rates to domestic prices.

Theoretical and econometric framework

The law of one price suggests that price transmission is complete, with the prices for an identical good at different locations differing by no more than the costs of trading the good between those locations (Fackler and Goodwin 2001). A complete price pass-through is attained by trade. Profitable trade arbitrage will swiftly erase any price difference across spatially separate marketplaces above transaction cost by physically moving the goods between the markets until the disparity is below transaction costs. And is given by:

$$P^d = P^e + T = P^w \tag{1}$$

where P^d is the price in the domestic (importing) market, P^e is the price in the exporting market, T is the transport and other transfer costs involved in moving goods between the markets, and P^w is the trade price of imported goods. If a country imposes no transmission-impeding policies, the domestic price for a good (P^d) in the importing country is determined by the trade price (P^w) times the exchange rate (X) and *ad valorem tariff*; that is, $P^d = P^l$, where P^l is duty included in the landed price expressed in local currency.

$$P^d = P^l = [P^w X(1+t)] \tag{2}$$

The value for the price transmission elasticity (ε) between the domestic and landed prices, that is, the percentage change in P^d with a 1% change in P^l, can be expressed as:

$$\varepsilon = \frac{\dot{P}^d}{\overbrace{\left[P^W X(1+t)\right]}^{\bullet}} \tag{3}$$

where a "dot" above the variable in equation (3) indicates a percentage change; we follow the methodology developed by Liefert (2011) to decompose the changes in the domestic market prices in equation (3) into the effect of changes in trade prices of wheat, exchange rates, and agricultural trade policies (e.g., *ad valorem tariffs* in the case of imports). To isolate the effect of incomplete transmission from equation (3), following Liefert (2011), we expand the price transmission elasticity from ε to $(\varepsilon + k - k)$, where $k = 1 - \varepsilon$, such that $\varepsilon + k = 1$. This gives us:

$$\dot{P}^d = \underbrace{\overbrace{\left[P^W X(1+t)\right]}^{\bullet}}_{\mathbf{A}} - k \underbrace{\overbrace{\left[P^W X(1+t)\right]}^{\bullet}}_{\mathbf{B}} \tag{4}$$

The term B in equation (4) becomes zero if the transmission from a change in the landed price P^l to P^d were complete ($\varepsilon = 1, \ \textit{such that } k = 0$). Equation (4) isolates and measures the effect on P^d assuming that transmission is complete (as measured by term A), as well as the effect on P^d arising from *incomplete transmission* (the term B of the Equation). The term B in equation (4) measures the degree to which incomplete transmission cuts into the potential change in P^d. The sum of these two parts (i.e., A and B of equation (4)) gives the *net effect* based on the actual value of ε (transmission elasticity). To measure the share of percentage change in P^d caused by and attributed to the percentage change in P^w, X, *and* t in the final form of the decomposition equation, no term should contain the percent change of either a sum or product of two or more of the above variables. One can break the term A in equation (4) by using the expression $\dot{X} = \frac{\Delta X}{X_1}$. This gives the following equation:

$$\overbrace{\left[P^W X(1+t)\right]}^{\bullet} = \frac{\Delta\left[P^W X(1+t)\right]}{P^W X(1+t)}$$

And further,

$$\frac{\Delta\left[P^W X(1+t)\right]}{P^W X(1+t)} = \underbrace{\frac{\Delta\left(P^W X\right)}{P^W X(1+t)}}_{\mathbf{C}} + \underbrace{\frac{\Delta\left(P^W t\right)}{P^W X(1+t)}}_{\mathbf{D}} \tag{5}$$

The term C of equation (5) can be further simplified by using the following mathematical rule:

$$\begin{aligned}\Delta(XY) &= \bar{X}\Delta Y + \Delta X\bar{Y} \\ &= \left(\frac{(X_1+X_2)\overset{\bullet}{Y}Y_1}{2}\right) + \left(\frac{(Y_1+Y_2)\overset{\bullet}{X}X_1}{2}\right)\end{aligned}$$

Applying the above rule to equation (5) results in the following expression:

$$\frac{\Delta\left(P^W X\right)}{P^W X(1+t)} = \frac{\overset{\bullet}{P^W}P^W(X_1+X_2)}{2\left[P^W X(1+t)\right]} + \frac{\overset{\bullet}{X}X\left(P_1^W+P_2^W\right)}{2\left[P^W X(1+t)\right]} \tag{6}$$

Equation (6) measures the change in P^d from the *direct price effect* that occurs from ΔP^w and ΔX. Similarly, the term D of equation (5) can also be broken into the following:

$$\underbrace{\frac{\Delta\left(P^W X\right)}{P^W X(1+t)} = \frac{\overset{\bullet}{t}t\left(P_1^W+P_2^W\right)(X_1+X_2)}{2\bullet 2\left[P^W X(1+t)\right]}}_{\mathbf{E}} + \underbrace{\frac{\overset{\bullet}{X}X\left(P_1^W+P_2^W\right)(t_1+t_2)}{2\bullet 2\left[P^W X(1+t)\right]}}_{\mathbf{F}} + \underbrace{\frac{\overset{\bullet}{P^w}P^W(X_1+X_2)(t_1+t_2)}{2\bullet 2\left[P^W X(1+t)\right]}}_{\mathbf{G}} \tag{7}$$

Equation (7) gives the *policy effect* on P^d and has three parts. The sub-term (E) associated with $\dot{t}t$ in equation (7) measures the change in P^d resulting from changes in the tariff (i.e., explicit policy effects). The sub-terms 7 (F) and (G) are associated with $\dot{X}X$ and $\dot{P}^wP^w$ and measure the change in P^d resulting from changes in trade prices (ΔP^w) and exchange rates (ΔX) interacting with the tariff rates (i.e., implicit policy effects). The magnitudes of both the direct price and policy effect assume a complete transmission of change in the landed price P^l to domestic prices P^d. Similarly, the incomplete transmission effect on domestic prices (P^d) is given by the term B in equation (4). It measures the change in domestic prices (P^d) resulting from changes in trade prices (ΔP^w), changes in exchange rates (ΔX), and changes in the *ad valorem* tariff rates (Δt) interacting with market conditions, resulting in an incomplete price transmission to domestic prices (P^d).

Data description

We apply the decomposition model to the real domestic market prices (P^d) for Indian wheat. The 2006/07–2008/09 and 2017/18–2019/20 period was chosen for several reasons. First, both periods involved a fair amount of movement in real trade prices. For instance, during 2006/07–2008/09, wheat trade prices (in real terms) increased by 12%. Similarly, it witnessed a marginal decrease of around 5% from 2017/18–2019/20. Second, the periods witnessed a substantial movement in the effective rate of basic customs duty. For instance, the basic customs duty rate on imported wheat decreased (increased) by 100% (176%), from 50% to zero (14.17% to 39.17%) in response to rise (decline) in trade prices during

2006/07–2008/09 (2017/18–2019/20). Third, India's wheat imports reduced substantially, approximately 1.65 MMT, between 2017/18 and 2019/20 due to increased tariff rates.

The data on domestic market prices (P^d) were collected from the report on *Agricultural Prices in India*, published by the *Directorate of Economics and Statistics*, *the Ministry of Agriculture*, *and the Government of India*. The prices refer to the month-end wholesale market price of the average quality of wheat in Uttar Pradesh (Kanpur). We determine the real value of domestic prices by dividing the nominal prices by the Consumer Price Index, using a base of 2010 = 100 for all Indian items. The international wheat price refers to free-on-board the US Gulf price of Hard Red Winter (HRW) No. 2. We collected the data from the Global Information and Early Warning System database of the Food and Agriculture Organization. We determined the real values by dividing the nominal prices by the Consumer Price Index for all items in the USA, using a base of 2010 = 100. We collected data on monthly average exchange rates (national currency per US dollar) from the International Financial Statistics of the International Monetary Fund. We determine the real value of the exchange rate by multiplying the nominal values by the ratio of the USA to India's consumer price indices, using a base of 2010 = 100. We compiled data on the effective rate of basic customs duty (ad valorem import tariff) on wheat from the Directorate of Economics and Statistics, the Ministry of Agriculture, and the Government of India.

To estimate the trade price for imported wheat, we added the international ocean freight charges (from the US Gulf port to the Indian port, i.e., Visakhapatnam) to the FOB US Gulf price for US HRW No. 2. We have adjusted the domestic price for domestic transport and transaction costs under the importable hypothesis, assuming that these costs are same to both imports and domestic output by following the methodology developed by Pursell, Gulati, and Gupta (Pursell, Gulati, and Gupta 2009) and Saini and Gulati (2017). We took the domestic marketing costs and traders' margins to be 6% of the domestic price.

Results and discussions

The first step in decomposition analysis is estimating the price transmission elasticity using equation (3) between the landed price $[P^w X(1+t)]$ and the domestic price (P^d) over the period 2006/07–2008/09 and 2017/18–2019/20. The price transmission elasticity for 2006/07–2008/09 shows a poor transmission of price signals between landed and domestic prices (price transmission elasticity = 50%). In the 2017/18–2019/20 period, the price elasticity of transmission was around 67%, which shows that over the period, the pass-through of changes from the landed price to domestic markets has improved significantly. In comparison, Tripathi's (2013) study found a price transmission elasticity of 30% for Indian wheat for the 2001–2004 period. Thus, findings from the current study demonstrate an improvement in the pass-through of changes to the domestic wheat market over the period.

The improvement in the price transmission elasticity could be attributed to the gradual liberalization of India's agricultural trade policies, which allow trade price and exchange rate transmission. Additionally, over the last two and a half decades, India has made significant progress in its agricultural market infrastructure[11], with the government investing in a variety of schemes and initiatives to address the critical

[11]Market liberalization could lead to efficient trade flows and reduced friction in the movement of money, goods, and labor. Additionally, financial reforms in India led to easier and increased avenues for foreign direct investment. The increased confidence in market reforms and investment by individuals, companies, and banks have led to increased investment in infrastructure in India, both public and private.

infrastructure gap.[12] With the large-scale plan expenditure of the government, both the physical marketing infrastructure, such as roads and transport, storage, and market facilities, and digital infrastructure have significantly expanded in the country over the years (Chatterjee and Kapur 2017; Ghosh 2017; Chand 2012; NABARD 2021). Appendix Table A1 provides a timeline of the policy measures adopted toward the development of agriculture infrastructure. Nonetheless, the accumulation of stock with public agencies has an influence on market prices by reducing the risk associated with a price decline. It could potentially lead to a situation where falls in international prices are passed on at a comparatively slower pace, in addition to state trading requirements.

After incorporating the price transmission elasticity into the model, the analysis results for both periods are presented in Table 1. Column 1 of Table 1 shows the four variables (trade prices, exchange rates, trade policy, and domestic wheat prices) used in this study. Column 2 of Table 1 shows the actual percent change in real domestic prices (P^d) and the variables that determine domestic prices. The column shows that during the period of price surge (2006/07–2008/09), the domestic price of Indian wheat decreased by 14% in real terms. The real trade price (P^w, in US dollars) increased by 12%, and the real exchange rate (rupees/dollar) decreased by 7%. The 100% fall in t resulted from a decrease in the import tariff rate from 50% to zero. However, between 2017/18 and 2019/20, the domestic price of Indian wheat increased by 16%, P^w decreased by 4%, and the real exchange rate increased by 6%. An increase in the import duty from 14.17% to 39.17% resulted in a 176% increase in t.

The price elasticity of transmission estimate suggests incomplete transmission of changes in trade prices, exchange rates, and trade policy on domestic wheat prices in both periods. Column (–k) 3 of Table 1 measures the incomplete transmission effect of change in trade prices (P^w), exchange rates (X), and tariffs (t) on domestic wheat prices (P^d). For instance, a decrease in trade prices (P^w) decreased domestic wheat prices (P^d). During the period 2006/07–2008/09, however, due to incomplete transmission, the failure of domestic wheat prices (P^d) to increase by the potential maximum (under complete price transmission – column 6) has the attributable impact of a decrease in domestic wheat prices (P^d) by 5%. Likewise, decreased exchange rates (X) and tariff rates (t) decrease domestic prices. However, because of the incomplete transmission, the failure of domestic wheat price (P^d) to fall to its maximum potential with a decrease in exchange rates (X) and tariff rate (t) has the attributable effect of increasing domestic wheat prices (P^d) by 4% and 17%, respectively. Finally, the aggregate combined impact of the changes in P^w, X, and t with incomplete transmission increases domestic wheat prices (P^d) by 16%. Similarly, for the period 2017/18–2019/20, incomplete transmission results in P^d not decreasing to its maximum potential due to a decrease in P^w, due to the attributable effect of increasing P^d by 2%. Likewise, a rise in X and t has the attributable impact of decreasing P^d by 2% and 7%, respectively. Thus, the aggregate effect is to decrease P^d by 7%.

The other three columns (i.e., col. 4–6) under "e + k = 1" measure the degree to which changes in the trade prices (P^w), exchange rates (X), and tariffs (t) change the domestic wheat price (P^d) under the complete transmission of changes. The direct price effect column (column 4 of Table 1) measures the impact of changes in trade price (P^w) and exchange rate (X) on domestic wheat prices (P^d). Through this effect, during the period 2006/07–2008/09, an increase in trade prices (P^w) increases the domestic price of wheat by 8%. In contrast, a fall in exchange rates (X) decreases domestic prices by 5%. Thus, the

[12]For example, Agricultural Marketing Infrastructure (AMI) Scheme, Agriculture Infrastructure Fund (AIF) Scheme, Pradhan Mantri Kisan Sampada Yojana, National Agriculture Market, and establishment of Agri Export Zones (AEZs) to name a few.

Table 1. Decomposition of change in the real market price for Indian wheat

		Contribution of % change in V to % change in P^d				
		–k	e+k = 1			e
Variable (V)	% Change in V	Incomplete transmission effect	Direct price effect	Policy (tariff) effect	Complete transmission effect	Net effect
Col. 1	Col. 2	Col. 3	Col. 4	Col. 5	Col. 6	Col. 7
Wheat 2006/07–2008/09; price transmission elasticity = **50%**						
P^w	12	–5	8	3	11	6
X	–7	4	–5	–2	–7	–3
t	–100	17	na	–34	–34	–17
P^d	–14	16	3	–33	–30	–14
Wheat 2017/18–2019/20; price transmission elasticity = **67%**						
P^w	–4	2	–4	–1	–5	–3
X	6	–2	5	1	6	4
t	176	–7	na	22	22	15
P^d	16	–7	1	22	23	16

(Source: Author's calculation)

aggregate direct price effect of changes in trade prices and exchange rates increases domestic wheat prices (P^d) by about 3%. Likewise, during the period 2017/18–2019/20, the aggregate direct price effect of changes in P^w and X, increases P^d by about 1%.

The policy effect column (column 5 of Table 1) measures the explicit and implicit effect of policy changes (changes in tariff) on domestic wheat prices (P^d). Indeed, from 2006/07–2008/09, decreasing the tariff rates decreases domestic wheat prices (P^d) by 34%. With an *ad valorem* tariff, changes in both the trade price (P^w) and exchange rates (X) create an implicit policy effect on domestic wheat prices (P^d) because the above changes alter the value of the imported wheat assessed by the tariff. Changes in P^w have the implicit policy effect of increasing domestic wheat prices (P^d) by 3%. On the other hand, changes in the exchange rate have the implicit policy effect of decreasing domestic wheat prices (P^d) by 2%. The aggregate policy (tariff) changes decrease domestic wheat prices (P^d) by 33%. However, the aggregate policy (tariff) effect (implicit plus explicit) during 2017/18–2019/20 is to increase domestic wheat prices (P^d) by 22%.

Column 6 of Table 1 shows the scenario of a complete transmission. The total contribution of changes in trade prices of wheat (P^w), exchange rates (X), and tariffs (t) during 2006/07–2008/09 changed the domestic wheat prices (P^d) by 11%, –7%, and –34%, respectively. The combined effect of changes in all variables decreases the domestic wheat prices by 30%. Likewise, the total contribution of changes in P^w, X, and t during 2017/18–2019/20 under complete transmission is to increase the domestic wheat prices by 23%. Comparing incomplete and complete transmission (columns 3 and 6 of Table 1) during 2006/07–2008/09 reveals the failure of domestic wheat prices (P^d) to fall to their potential maximum. Thus, because of incomplete transmission, domestic prices fall less (16%) than they could have been in complete transmission (30%). Likewise, during 2017/18–2019/20,

due to incomplete transmission, domestic prices rose less (7%) than they could have been in complete transmission (23%).

The last column of Table 1 (column (e)) shows the net effect of changes in the trade prices (P^w), exchange rates (X), and tariffs (t) on domestic wheat prices (P^d). The numbers in this column are the sum of the values in the incomplete transmission effect (column 3) and complete transmission effect (column 6).[13] For the period 2006/07–2008/09, the results show that the net attributable impact of the rise in trade prices (P^w) increases the domestic wheat price (P^d) by 6%. Similarly, the net attributable implications of a fall in exchange rates (X) decrease the domestic price of wheat (P^d) by 3%. The net attributable effect of the fall in tariff rates (t) decreases the domestic price of wheat (P^d) by 17%. The net result of changes in trade prices (P^w), exchange rates (X), and tariffs (t) is a decrease in the domestic price of wheat (P^d) by 14%. Similarly, the net attributable effect of changes in trade prices (P^w), exchange rates (X), and tariffs (t) during 2017/18–2019/20 is an increase in the domestic price of wheat (P^d) by 16%.

In sum, the analysis of changes in domestic wheat prices over the periods 2006/07–2008/09 and 2017/18–2019/20 highlights that in both periods, poor transmission of changes in P^w and X on domestic prices has precluded much of the potential price changes. However, the pass-through of changes from the landed price to domestic markets has improved significantly over the period. The last two and a half decades have witnessed India moving away from trade policies that prevent or lower price and exchange rate transmission. However, supporting domestic agriculture policy objectives remains the prime concern of India's trade policy. Accordingly, policy makers adjusted trade policy instruments from time to time to regulate trade volumes depending on domestic supply and prices. During the study periods, customs duty of wheat varied depending upon trends in world wheat prices. Though India has made significant progress in addressing the critical infrastructure gap, the facilities continue to be inadequate, hence affecting supply chains and resulting in incomplete transmission of changes between landed and domestic wheat prices. Additionally, the public stockholding of wheat has an influence on market prices by reducing the risk associated with a price decline. It could potentially lead to a situation where falls in international prices are passed on at a comparatively slower pace.

Conclusion and policy implication

Over the past two decades, starting from the world food price crisis of 2007–08, international grain prices have witnessed a significant fluctuation due to increased uncertainty caused by supply shocks due to adverse weather conditions, the outbreak of COVID-19 in 2019, and most recently, Russia's aggression against Ukraine since early 2022. Like many other countries, India also tried to mitigate the effect of fluctuations in world food prices on domestic prices through countervailing policy changes. The present study estimates the extent to which variation in domestic food prices is due to fluctuations in the exchange rate, world prices, and sector-specific trade policies. The analysis was conducted under the scenario of incomplete transmission of changes and the counterfactual scenario of complete transmission of changes in world prices and exchange rates. The study used data on the Indian wheat market prices for the periods 2006/07–2008/09 and 2017/18–2019/20 and relied on the theory of spatial market equilibrium and the methodological framework developed by Liefert (2011).

[13]Note that the sum of the net impact of changes in P^w, X, and t on P^d equals the sum of the direct price, policy, and incomplete transmission effects on the domestic price of wheat (P^d).

Findings from this study revealed an improvement in the pass-through of changes from the landed price to domestic markets over the years. The price transmission elasticity increased from 50% in 2006/07–2008/09 to 67% during 2017/18–2019/20. The findings could be attributed to the gradual liberalization of India's agricultural trade policies and progress made over the years toward agricultural market infrastructure, with the government investing in a variety of schemes and initiatives. The results also showed that the policy response to changes in world prices by reducing/raising import tariffs has canceled out much of the effect on domestic prices from a rise or fall in world prices.

Due to incomplete transmission of changes, Indian wheat prices responded less than they could have been with complete transmission. Though the decomposition method cannot identify the cause of the incomplete transmission, the analysis results and discussion on India's wheat market indicate that the efforts made by the government toward addressing the critical infrastructure gap and gradual liberalization of agricultural trade policies have improved the pass-through of changes of trade prices and exchange rates. Nonetheless, existing interventions, such as price support and procurement, along with inadequate infrastructure facilities, could be responsible for the incomplete pass-through of changes.

Data availability statement. The data that support the findings of this study are available from the authors.

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Appendix

Table A1. Timeline of rural and agri infrastructure development policy measures, India

Year	Policy measure	Highlights
1995	Rural Infrastructure Development Fund (RIDF)	Covers 36 activities under three broad categories: (i) Agriculture and related sectors, (ii) rural connectivity, and (iii) social sector.
2000	Pradhan Mantri Gram Sadak Yojana (PMGSY)	To provide all-weather road connectivity to eligible unconnected habitations. Total road length completed: 6.6 lakh km; PMGSY-III target: 1.3 lakh km; connectivity to Gramin Aagri Mandis, schools, hospitals
2001	Agricultural Marketing Infrastructure (AMI) scheme, 2001	To provide assistance for the construction or renovation of godowns and warehouses in rural areas to boost agricultural storage capacity
2003	Agricultural Produce Marketing (Development and Regulation) Act	Establishment of private/cooperative markets, direct marketing, contract farming, establishing farmer/consumers market, single point levy of market fee, constitution of State Agricultural Produce Marketing Standards Bureau, and single unified trading license in mandis across the state
2005	Rajiv Gandhi Grameen Vidyutikaran Yojna (RGGVY)	Providing access to electricity to all rural households over a period of four years
2006	Mahatma Gandhi National Rural Employment Guarantee Act (MGNREGA)	Legally guarantee 100 days of unskilled jobs per rural household
2010	The Warehousing Development and Regulatory Authority (WDRA)	To establish a negotiable warehouse receipt system in the country
2011	Bharat Net project	To provide broadband connectivity to all Gram Panchayats in India
2016	Electronic National Agriculture Markets (e-NAMs) 2016	Integration of Agriculture Produce Marketing Committees (APMC) mandis and providing multifaceted benefits to farmers, farmer-producer organizations, buyers, and traders in APMC mandis
2016	Pradhan Mantri Gramin Awaas Yojana	Housing for all by 2022; target 2.2 crore houses; sanctioned: 2 crores; completed: 1.4 crore
2016	SP Mukherjee Rurban Mission	Develop 300 rurban clusters in 35 states and Union Territories
2017	Pradhan Mantri Kisan Sampada Yojana	To integrate cold chain, food processing, and preservation infrastructure. Highlights – Mega Food Park; integrated cold chain; Operation Greens
2019	Jal Jeevan Mission	15.7 crore (83%) rural Households to be provided functional tap water connection by 2024
2020	Agriculture Infrastructure Fund (AIF), 2020	Aims to enhance post-harvest management infrastructure, minimize losses, increase farmers' income, and bring innovation to agriculture

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