INITIATIVE ON
Transforming Agrifood Systems in South Asia

Analyzing Crop Price Dynamics in Nalanda, Bihar: An In-Depth Analysis of Twenty Agricultural Commodities

Research Note 20 December 2023

SUMMARY

In this study, we investigated market integration and price transmission dynamics in agricultural supply chains in Nalanda, Bihar, focusing on twenty commodities. We utilized daily price data from Noorsarai and Harnaut village markets, the Bihar Sharif intermediate market, and the Patna City market with the aim of understanding the interrelationships among these prices. Our findings suggest that most crop prices tend to vary concurrently, necessitating adjustments for improved precision and accuracy in price assessments. We also observed notable linkages between smaller village markets and larger markets, influenced by factors such as minimum support prices and transportation costs. Through causality tests, we identified bidirectional influences in certain markets, revealing the complex nature of price transmission dynamics. These insights can contribute to a better understanding of inter-market price relationships, potentially aiding policymakers in refining Bihar's agricultural supply chains such that they can better support farmgate prices received by smallholder farmers. More generally, this work provides practical insights on how prices can be better aligned between diverse value chain actors, including smallholder farmers, traders, and marketers in India's agricultural markets. This work highlights how price dynamics and market integration that can be studied in a variety of contexts beyond Nalanda, Bihar, and which are important to aid in making informed decisions about crop production, pricing, and market access, particularly for smallholder and marginalized farmers.

Above: Team visit during land preparation, planting method, seed treatment, and basal fertilizer dose application at Meyar and Kairi, Nalanda, Bihar; Photo Credit: Manish Kakraliya

CIMMYT · IFPRI International Food Policy Research Institute · IRRI International Rice Research Institute · IWMI International Water Management Institute · CIP International Potato Center

BACKGROUND

Effective agricultural marketing systems are vital for enhancing farmers' returns on their investments, stimulating agricultural production, and fostering diversification at the farm level by offering valuable insights into commodity prices. (Ladele and Ayoola, 1997 and Obalyelu and Alim, 2013). Since agricultural prices tend to fluctuate throughout the year as a function of seasonality and changes in demand, effective planning becomes essential, particularly for smallholder farmer producers and poor consumers (Obalyelu and Alim, 2013). In a perfectly competitive market, smooth transmission of prices across spatially separated markets is expected, where prices in a deficient and non-competitive market theoretically equal prices in the surplus market plus the transfer cost (Chowdhury et al., 2005). This seamless price transmission would theoretically aid farmers in expanding the production of commodities with a comparative advantage and benefiting from the trade of these commodities, so long as they can respond by investing in profitable commodities (Baulch, 1997). Understanding market integration can enable efforts to assist farmers in capitalizing on the opportunities for profit through inter-commodity trading. It can also aid in predicting farm prices by tracking price fluctuations in intermediary and urban markets (Okoh and Egbon, 2005).

In India, urban food markets have undergone remarkable evolution in the past two decades in response to changing consumer demands for convenience, health, and value-oriented commodities (Pingali, 2007; Reardon, Chen, et al., 2014; Reardon, Tschirley, et al., 2014; and Reardon & Timmer, 2014), However, village-level markets have not been able to keep up with the changes in urban markets. This may be due to a a series of challenges such as a lack of adequate storage and transportation, unregulated markets, lack of grading, lack of market information to enable mutually beneficial trading, and poor access to finance. As a result, commodity markets or supply chains remain inefficient, leading to higher transaction costs and lower producer surplus compared to what producers would have received with a more efficient market. This can have the additional effect of reducing consumer surplus due to elevated prices driven by increased transaction costs.

Above: Seed potato received by farmers at Meyar village, Nalanda, Bihar; Photo Credit: Manish Kakraliya

In this study, price transmission and the market integration of 20 agricultural commodities in Nalanda district of Bihar were examined along the supply chain. These commodities were chosen as they emerged as the crops grown by farmers in the region in the inception workshops at the beginning of the pilot. The villages of Noorsarai and Harnaut, designated as Small Farmers Large Field (SFLF) pilot sites, are selected as the primary village or block markets (mandis) where farmers sell their harvested products. Local consumers and traders from Bihar Sharif mandi, the next level of the intermediate aggregation market, are the primary buyers at these village-level markets.

The SFLF approach is being piloted by Transforming Agrifood Systems in South Asia (TAFSSA) as a farmer collective action model that aims to improve smallholder farmer livelihoods by engaging farmers to benefit from economies of scale by organizing themselves into producer groups. This The model aims to address some of the challenges faced by small and marginal farmers, such as diseconomies of scale and limited bargaining power within the supply chain.

The final stage in the supply chain in our study is the Patna City mandi, which functions as the destination market for these commodities. This is because it serves as the wholesale market for retailers in Patna City. It therefore holds an important role in influencing the overall pricing dynamics for the examined agricultural products. However, a lack of high-frequency time series data for such markets in Bihar and more generally developing countries limits previous studies, making this research unique and valuable. In response to these practical challenges, this research has three primary objectives: (i) to analyze short-run and long-run price relationships among local, Bihar Sharif, and Patna mandi prices for each commodity, (ii) to examine causality between local and Bihar Sharif mandi prices and Bihar Sharif mandi and Patna wholesale market prices, and finally, (iii) to determine the asymmetric price response to economic hocks after causality is determined.

Features of agricultural commodity supply chains in Bihar

Describing multiple commodity marketing channels in a single framework poses a range of challenges. For example, marketing channels for perishable commodities like tomatoes, or semi-perishable commodities such as onion and potatoes differ from those of non-perishable or storable commodities such as rice and wheat. Furthermore, certain village markets may exhibit a net surplus of one commodity while experiencing a net deficit of another, leading to the flow of products from one village to another as well as from a village to an urban market. Despite these issues, we map probable marketing channels identifying the flow of commodities among the four markets in Figure 1.

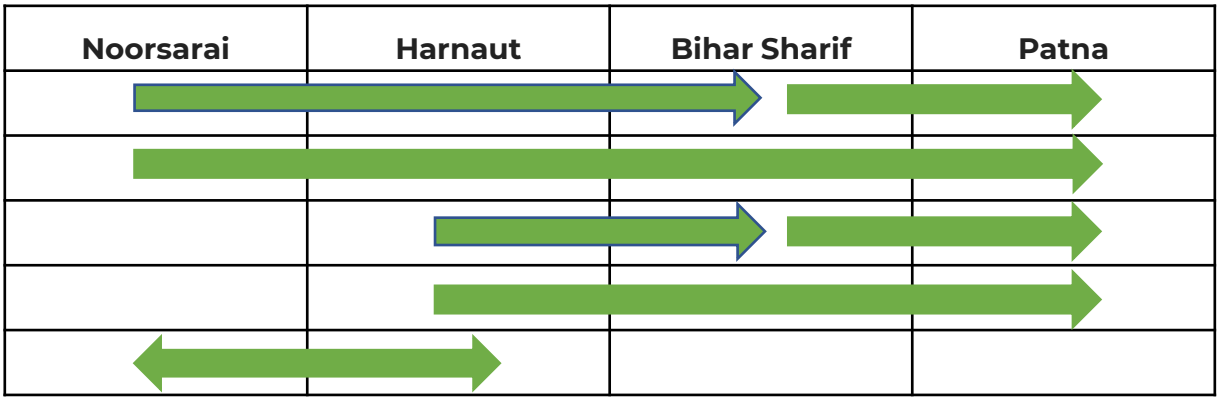


Figure 1: Hypothetical flow of agricultural commodities between markets in Bihar, India

One of the most common market characteristics of these channels is the presence of middlemen traders. In India, middlemen are intermediaries who facilitate the exchange of agricultural products between farmers and consumers. Middlemen often purchase goods from farmers at the farm gate, but are also involved in product aggregation, storage, and transportation. Except for commodities purchased locally for immediate consumption, most agricultural goods produced by farmers are at least in part sold to local traders. The second important market feature is that village and urban markets are weakly connected due to poor transportation infrastructure, resulting in incomplete information and price asymmetry between rural and urban markets (Singh 2010).

One may argue that farmers may have somewhat more improved farmgate ability to negotiate with middlemen for fairer prices powers because of the recent evolution of digital communication tools such as mobile phones and internet that can be used to access price information from distant markets. However, most farmers in the study are smallholders; and despite the availability of price information, it is challenging to negotiate for better prices with more powerful middlemen or to bypass local traders because of diseconomies of scale. The cost of transporting their relatively small volume of produce is significantly higher than the benefits they would gain by venturing into larger markets (KC and Jamir, 2018).

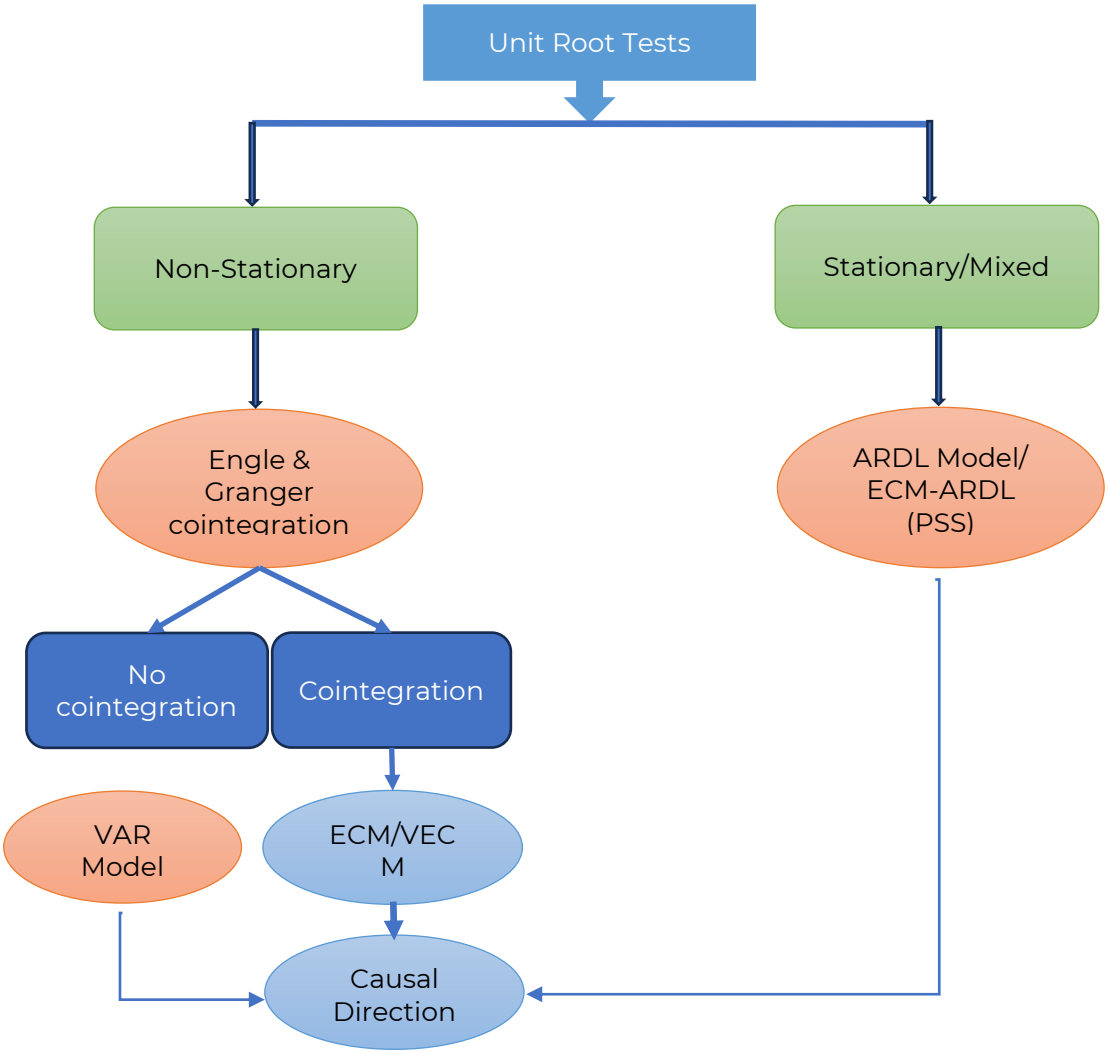
A key reason for this dilemma may be that some farmers need to sell their products quickly to pay back loans and to purchase essentials because they do not have alternative income sources. Second, bigger markets are far from many villages, resulting in an additional cost associated with returning their products if traders do not accept the spot prices when farmers transport goods to larger markets. Importantly, some products, particularly vegetables such as tomatoes, spinach, and others, must be sold immediately due to their perishable nature. The lack of cold storage facilities is another market challenge.

METHODOLOGY

Empirical Framework

This study specifies an appropriate dynamic adjustment model to understand the causality and long-term adjustment process of four markets (two village markets, one district level intermediate wholesale market and the final city market) after testing for non-stationarity and cointegration relationships between each pair of price series. Figure 2 illustrates the methodological framework used for study, which suggests that if two prices are non-stationary and cointegrated, the dynamic adjustment model is specified as a linear Vector Error Correction Model (VECM). Second, if the two prices series are non-stationary but not co-integrated then VAR models are used for understanding causality. Finally, if one price series is stationary and the other variable is non-stationary or both price series are stationary, we applied an autoregressive distributed lag (ARDL) model to determine causality.

Figure 2: Schematic presentation of the modelling framework applied in this study. VAR = Vector Autoregressive; EG = Engle-Granger; ECM = Error Correction Model; ARDL = Autoregressive Distributed Lag; PSS = Pesaran, Shin, and Smith (2001), which is an ECM version of ARDL model.



DATA AND DESCRIPTIVE STATISTICS

This study examined the daily prices of 20 agricultural commodities across four markets in Bihar, spanning cereals, vegetables, and oilseed crops. The markets consist of two rural (village or block) markets, namely Noorsarai and Harnaut, and two urban markets, Bihar Sharif and Patna. The selection of these markets was based on the information obtained during the inception workshops at the beginning of the pilot.

The Agmarknet portal, initiated by the Government of India, is the primary data source of market information in India. This database offers a platform for collecting and publishing information on prices and arrivals across wholesale markets since its launch in 2000. Yet despite its coverage, a closer examination of the Agmarknet daily price reports reveals a lack of data for Bihar's village level markets in 2021. Although some markets were incorporated in 2022 and additional markets were added by the end of that year, none from the Nalanda district were included. Notably, missing data can also be observed across various crops and markets, indicating gaps in the reporting that need to be addressed.

To address some of the limitations of Agmarknet, daily prices for certain commodities, particularly those not extensively covered, were collected from traders' personal record books in each of the four markets in our study locations. Trained enumerators worked with traders from the period from January 1, 2021, to April 30, 2023, with a total sample size of 789 traders.

While some commodities, such as rice, wheat, maize, mustard, mung bean, potato, onion, and okra, have complete series price information, comprehensive price information records were challenging to obtain.

For this reason, 12 commodities still have some missing observations for certain markets, with the smallest sample size for field peas at 430 observations.

PRELIMINARY RESULTS AND INSIGHTS

Our analysis followed a three-step approach. Firstly, the non-stationarity of price series was examined using augmented Dickey-Fuller (ADF) and Philip Perron (PP) tests. Secondly, cointegration of non-stationary price pairs is explored via the Engle-Granger approach. Thirdly, causality directions between markets for different commodities are presented, shedding light on market price transmission dynamics. The following sections break down the results of the analysis of the prices of agricultural products in Bihar in more detail..

Verifying Price Stability

Daily commodity prices were assessed for stationarity using ADF and PP tests. This was done to identify if the prices of products remained steady or if they fluctuated. Our preliminary results, detailed in Table 1, suggest that most price series, except for a few exceptions like rice, wheat, maize, and mustard in the Patna market, are integrated into order one (I(1)), indicating the first differences are stationary.

Long-term Price Relationships

Once the stationarity of a price series was established, we employed the Engle-Granger to determine whether prices in different markets are connected over the long run.

Our preliminary results suggest that Noonsarai and Harnaut market prices for rice, wheat, maize, mung bean, mustard, potato, and onion are cointegrated with the nearby intermediate aggregation market, Bihar Sharif. They, however, do not appear to be integrated with the Patna market. For Okra, bottle gourd, coriander, cauliflower, cabbage, and brinjal, no cointegrating relationship was found. In other words, there appears to be no long-term relationship for these vegetable markets. For the remaining six commodities (tomato, red spinach, field pea, bitter gourd, and nainwa) some of the markets appear to be more cointegrated.

Understanding Market Influence

Lastly, we looked at how prices in one market affect others. The study used VEC and VAR models to conduct this analysis. Figure 3 indicates the results of this analysis for cointegrated markets.

Figure 3: Causal directions and long-run relationships for cointegrated markets using the VEC model. The direction of the arrows indicates the influence of prices between markets. Blank boxes indicate that the commodity and flow do not fall under the category of the table.. None indicates that no relationship was found

		Noor Sarai-Bihar Sharif	Harnaut-Bihar Sharif	Bihar Sharif-Patna	Noor Sarai-Patna	Harnaut-Patna	Noor Sarai-Harnaut
I.	Rice	⟷	←				
II.	Wheat	⟷	←				
III.	Maize	⟷	←				
IV.	Mungbean	⟷	←	→	→	←	
V.	Mustard	⟷	←	→	→	→	→
VI.	Potato	⟷	→	⟷	⟷	→	←
VII.	Onion	⟷	⟷				
VIII.	Tomato			→	⟷		
IX.	Red spinach	→	←				
X.	Spinach			←	←		
XI.	Cucumber						⟷
XII.	Field Pea		⟷	→	→	→	
XIII.	Bitter Gourd			⟷			
XIV.	Nainwa			⟷	→	NO DATA	

For example, the first row in Figure 3 indicates that the rice prices in Bihar Sharif and Noorsarai markets respond to changes in between these markets. However, Harnaut appears to follow price changes instead of influencing them. Potato prices, on the other hand, are strongly connected to all markets, especially influenced by Harnaut which influences the prices in both Bihar Sharif and Patna mandi. Village market prices of cereals (rice, wheat, and maize), mung bean, and mustard conversely appear to relate to nearby aggregator markets. The minimum support price policy, which is a guaranteed price offered by the Government of India to aid farmers against price volatility in the event of over production, for these commodities encourages farmers to sell their produce at nearby mandis rather than transporting them to the Patna market. The price influence pattern for other commodities can be observed in Figure 3.

For the price pairs that are non-stationary and non-cointegrated, the results are reported in Figure 4. Our preliminary analyses indicate that these price pairs don't have long-term equilibrium relationships and do not move together. The directional changes reported are short run by nature. In most cases, the price influence runs from Patna to Bihar Sharif and Bihar Sharif to village markets. In some cases, a bi-directional impact is found.

Figure 4: Causal Direction for Markets with Non-Stationary but Non-Cointegrated Price Series. Blank boxes indicate that the commodity and flow do not fall under the category of the table.. None indicates that no relationship was found

	Items	Noor Sarai-Bihar Sharif	Harnaut-Bihar Sharif	Bihar Sharif-Patna	Noor Sarai-Patna	Harnaut-Patna	Noor Sarai-Harnaut
I.	Rice						None
II.	Wheat						None
III.	Maize						None
IV.	Mungbean						→
V.	Onion						→
VI.	Tomato	None	None			None	↔
VII.	Red spinach			None	None	None	→
VIII.	Spinach	None	None			None	←
IX.	Cucumber	←	None	None	←	←	
X.	Okra	←	←	←	←	↔	↔
XI.	Field Pea	↔	↔		None	None	None
XII.	Bitter Gourd	None	↔		None	None	None
XIII.	Bottle Gourd	↔	NO DATA	None	↔	NO DATA	NO DATA
XIV.	Nainwa	↔	NO DATA			NO DATA	NO DATA
XV.	Coriander	↔	NO DATA	←	↔	NO DATA	NO DATA
XVI.	Cauliflower	None	NO DATA	←	←	NO DATA	NO DATA
XVII.	Cabbage	←	NO DATA	→	→	NO DATA	NO DATA
XVIII.	Brinjal	None	NO DATA	←	None	NO DATA	NO DATA

Finally, Figure 5. reports the results of price pairs which are either stationary or mixed using the ARDL model. The data shown here suggest that the influence of cereal prices and onion runs from all three markets to the Patna market.

Figure 5: Causal direction for stationary / mixed pairs

	Items	Bihar Sharif-Patna	Noor Sarai-Patna	Harnaut-Patna
I.	Rice	⇨	⇨	⇨
II.	Wheat	⇨	⇨	⇨
III.	Maize	⇨	⇨	⇨
IV.	Onion	⇨	⇨	⇨

Based on these preliminary findings, it can be provisionally concluded that there is a bi-directional correlation in commodity prices between the Bihar Sharif and Noorsarai markets, likely attributed to their closeness.

PRELIMINARY CONCLUSIONS AND IMPLICATIONS

Price transmission dynamics in the food marketing literature have been extensively analyzed (Meyer & von Cramon-Taubadel, 2004). However, previous studies are primarily based on monthly price data. Importantly, previous food marketing literature did not explore the price dynamics between rural to intermediate aggregation market and intermediate to urban markets, particularly in a developing country's context. The primary reason is the lack of high frequency data available at the village/block level markets. Therefore, the novelty of this research is three-fold: (i) examination of the price transmission process between village/block markets to district level market and district level market to a major city market.(ii) use of daily price series data collected from traders' dairy in all the four markets, covering from January 2021 to February 2023, and (iii) commodity level price transmission analysis for a total of 20 commodities.

Time series properties of all price series are examined for unit root to specify an appropriate dynamic price adjustment model. The results suggest that long-run relationships exist between the village markets (Noorsarai and Harnaut) and the Bihar Sharif market but not with the Patna market for cereals, mung bean, and mustard. The presence of minimum support prices (MSP) for these commodities can explain this, as farmers have no incentives to take these commodities all the way to the Patna market. In contrast, they can receive the same MSP in the nearby Bihar Sharif market. Although cereals, mung bean, and mustard prices between Noorsarai and Bihar Sharif and Harnaut and Bihar Sharif are cointegrated, the presence of bi-directional causality between Noorsarai and Bihar Sharif and unidirectional causality from Bihar Sharif to Harnaut, suggest that Noorsarai can influence cereals, mung bean, and mustard prices in Bihar Sharif but not Harnaut.

In other words, Harnaut is a price taker in cereals, mung bean, and mustard, whereas Noorsarai has the market power to influence Bihar Sharif prices. Similarly, in the case of vegetables, except for potato prices, Noorsarai seems to have the power to influence prices in Bihar Sharif and Patna, whereas Harnaut is a price taker. These findings are consistent because Harnaut is not a major producer of vegetables. However, in the case of potato prices, although the prices in all four markets are cointegrated, Harnaut seems to have a unidirectional casualty to influence prices in the other three markets. Unlike Harnaut, Noorsari potato prices are influenced by price changes in Bihar Sharif Patna markets.

Finally, since the results indicate a differential price adjustment process for each commodity along the marketing channel, a common intervention may not improve all commodities similarly. Therefore, commodity-specific intervention is suggested for an efficient marketing channel. Policymakers should also emphasize initiating policies that include the development of transportation and market infrastructure so that vegetables can be transported to Patna so that farmers receive higher prices for their produce. Once that happens, the degree of integration between rural and urban markets will improve leading to higher returns for farmers.

Above: On-farm discussion on Major Pests and Diseases with Farmers at Meyar, Nalanda, Bihar; Photo Credit: Manish Kakraliya

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