Supply Behaviour and Pricing of Selected Agricultural Commodities in India: Comparative Investigation into Exchange and Market Pricing System

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DEDICATED TO MY

"Parents"

"The light which lit up every nook and corner of my life"

"MY SWEETEST MOTHER"

And

"To serve whom was my dream and
dream of serving him remain forever"

"MY BELOVED FATHER"

Sher-e-Kashmir
University of Agricultural Sciences &Technology of Kashmir,
Faculty of Horticulture, School of Agricultural Economics and
Horti-Business Management

Certificate – I

This is to certify that the thesis entitled, **"Supply Behaviour and Pricing of Selected Agricultural Commodities in India: Comparative Investigation into Exchange and Market Pricing System"** submitted in partial fulfilment of the requirements for the award of the degree of **Doctor of Philosophy in Agricultural Economics**, to the **Faculty of Horticulture, Sher-e-Kashmir University of Agricultural Sciences & Technology of Kashmir** is a record of bonafide research work carried out by **Mr. Mohammad Mubashir Kachroo (Regd. No. 2018-802-D)** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

It is further certified that information received during the course of investigation has duly been acknowledged.

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Certificate – III

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ABSTRACT

The present investigation entitled "Supply Behaviour and Pricing of Selected Agricultural Commodities in India: Comparative Investigation into Exchange and Market Pricing System" was based upon secondary data. The secondary data was collected from the website of NCDEX, the published documents of SEBI and the market data compiled by the CMIE database. In accordance with the objectives and data availability Compound Growth Rate, Unit root test, Seasonality analysis, Johansen's cointegration test, Parametric, Non-parametric and semi-parametric tests and Granger causality test was employed to analyze the data during the year 2020-2021.

Results revealed that there has been a positive trend in the prices of most of the selected agricultural commodities in the recent years, where futures market has played a leading role in price discovery function and information processing. The highest Mean futures price was seen in case of Cumin (₹13053.42) followed by Turmeric (₹5862.55) and lowest in case of Castor seed (₹2834.99) respectively. The behaviour of prices in response to arrivals for selected commodities was computed by using Compound growth rate, where it showed a positive and a significant growth rate for both prices and arrivals with Cumin showing the highest growth rate of (9.87%) in arrivals followed by Turmeric (9.05%) and the lowest in Coriander (5.06%) as against the prices where it showed all together a different scenario with highest in case of Coriander (7.55%) followed by Soybean (7.24%) and lowest in Cumin with (5.69%) respectively. The effect of seasonality on the prices was observed during the peak season because of the high post-harvest arrivals. A reverse relationship between prices and arrivals of all the selected agricultural commodities was observed. The stationarity of the prices and arrivals was done using ADF unit root test, the results of which revealed that all the selected commodities are stationary at first difference and non-stationary at level. The cointegration test results revealed that all the price series are cointegrated at 1% significance level. Both the trace test and maximum eigen test indicate identical results and hence support the cointegration between the futures prices and mandi spot prices with one-to-one long-run relationship for all the five commodities suggesting market efficiency in Indian agricultural commodity markets. The determinants of the prices revealed that out of 7 exogenous variables, 5 variables appear to have a significant role in the price discovery process at 5 per cent level of significance. All the specified exogenous variables explain above 90 per cent of the total variation in the prices of agricultural commodities except in case of Turmeric which showed above 50 per cent variation only. The non-parametric and semi-parametric regression test revealed that semi-parametric (spline) performs as the best fit model to examine the trend in the prices of the selected agricultural commodities. The short-run lead-lag relationship between futures and Mandi spot prices was performed using Granger causality test. A bi-directional causality was found in case of Cumin and Soybean, whereas, uni-directional causality was found in case of Castor seed, Coriander and Turmeric. Futures prices were found dominant in all the commodities indicating information gets first reflected in futures prices which then gets transmitted to Mandi spot prices proving that price discovery function occurs in futures market.

Based upon the findings of the study, there must be improvement in the storage facilities through improvement in warehouse structure, storage chambers in order to improve the retention capacity of the farmers. Government should ensure that there must be availability of reliable and consistent data about prices and arrivals on daily basis in different markets. The flow of market information must be speed up as the market information plays an important role in linking the distance markets. It will help in improving the marketing efficiency. Policymakers and regulators should emphasize the efficiency of futures markets and improve market participation by implementing appropriate trading strategies to enable the farmers and traders to take advantage of the information availability.

Keywords: Supply; commodities; spot prices; futures; growth; seasonality; stationarity; cointegration; efficiency; causality

Signature of Student | Signature of Major Advisor

Dated: __________ | Dated: ________________

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Mohammad Mubashir Kachroo

Place: Shalimar, Srinagar

Dated:

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Chapter-1

INTRODUCTION

Agriculture in India has grown rapidly enough in recent decades to move the country from severe food crises of the early 1960s to the surpluses of the early 1990s, even though there is an increase in the population. Studies analysing demand and supply of agricultural commodities are of fundamental importance in the domain of agricultural economics. The interest, in attempting a fresh review of the studies, in the area emanates from the fact that the structure of market in the agricultural sector as well as the decision environment is changing quite rapidly. The new scenario however does not necessarily out-date all the issues raised earlier but directs towards the requirement of analysing these issues in a changed perspective (Deshpande, 1996). The intrinsic requirement of any agricultural policy document is to understand the structure of demand of the commodities along with the elasticities for the purpose of projections and also the supply behaviour as reflected in the production decisions of the farmers in response to the economic stimuli. The academic interest in the studies on demand for and supply of agricultural commodities originated from three seemingly distinct but actually overlapping aspects. Firstly, a large number of studies were devoted to understand the nature of regional structure of commodity supply and demand as well as to obtain the forecasts of these, for example, Rao (1975), Government of India (1979), Patel and Vyas (1971), George (1980). Invariably, almost every study on the projections has utilised the estimates of price and income elasticities for the purpose. However, a few have effectively utilised only the past growth performance of related parameters to understand the future scenario. Secondly, the studies on behaviour of supply and demand mainly concentrate on understanding of the responses of commodities to various exogenous factors. These studies also rely on the computed elasticities with respect to price, lagged acreage, risk, technology, inputs and other such factors. The differences in these studies are mainly in the approach and methodology. Thirdly, the various regional characteristics and supply behaviour of various commodities become quite useful for the formulation of effective policy.

The agricultural framework in India has gone through significant changes over a long period of time owing to the adoption of green revolution advancements which took place between 1950 and the late 1960s, that increased the agricultural production worldwide, beginning most markedly in the late 1960s (Hazell, 2009). The key elements of the revolution include: 1) Use of last capital and technological inputs. 2) adoption of modern scientific methods of farming. 3) use of high yielding varieties of seeds. 4) proper use of chemical fertilizers and 5) consolidation of land holdings combined with price support policy of the government (Chand, 2003). After freedom, various approaches were attempted to secure the agricultural area that influenced the development in agricultural commodities. One of them being the Essential Commodities Act 1955, which conceived price and development security appropriate to different agricultural commodities, especially food grains like paddy, wheat, coarse grains and pulses to ensure the interests of producers as well as of consumers. During the process of economic liberalization, it was felt that there is a need to reorient policies and regulations in agricultural commodities. The Khusroo Committee was established which suggested the reintroduction of futures trading in most of the major commodities. The commodities include cotton, kapas, raw jute and jute goods and suggested that steps may be taken to introduce futures trading in various commodities at appropriate time (Khusroo Council, 1980).

In June 1993, The Government of India comprised another board of trustees headed by Professor K.N. Kabra on Forward Markets (Kabra, 2007). The board put emphasis on the requirement of futures trading in major 17 commodity groups covering a wide range of agricultural commodities. It likewise suggested fortifying of the Forward Markets Commission (FMC) and different revisions in Forward Contracts (Regulation) Act 1952 to bring fairness and efficiency in futures trading activities. The National Agriculture Policy declared in July 2000 envisaged domestic and foreign market changes by setting up an instrument of futures trading/market and destroying of all control and guidelines in agricultural commodity market (Sahadevan, 2002a). Subsequently, the Government of India gave notices on April 1, 2003 and allowed futures trading for a wide scope of agricultural commodities. Distress sale of agricultural commodities immediately after harvesting owing to lack of farmers capacity to wait for opportune time for getting remunerative prices and also because of the uncertainty involved in possible future prices has always remained one of the major concerns for producers and consumers (Sahadevan, Singh and Acharya, 2002b, 2001, 2001). Futures contracts help in performing two significant administration capacities, i.e., price discovery and price risk management for the particular product (Sahadevan, Kolamkar and Ahuja 2002c, 2003, 2006). Price discovery is the way towards uncovering data about future spot prices through the futures market. It is helpful for producers as they get a reasonable thought regarding the prices prone to win at a future point of time and thus, can use their restricted accessible assets among different contending commodities for improving their benefits. It likewise gives food processors and consumers a thought regarding prices at which the particular item would be accessible at a future point of time.

Despite the fact that futures trading in agricultural commodities were once again introduced in India in the year 2003, government is consistently skeptical about its effectiveness and likely effect on the price development of agricultural products. In April 2003 Futures trading permitted in all the commodities in three national level multi commodity exchanges i.e., MCX, NCDEX & NMCE established on e- platform. The prohibition on futures trading of some major agricultural commodities in February 2007 made it basic to investigate whether the futures market has truly accomplished its above-specified goals of price discovery and risk management or not. Theoretically, the relationship between spot and futures prices can be derived from the spot-future parity, which implies that spot and futures prices should move together across time to avoid constant arbitrage opportunities based on the spot-futures relationship (Hull, 1997).

Intuitively, since spot and futures prices for any commodity are driven by the same underlying information, they should be closely related. The exact nature of this relationship depends on many factors, among which seasonal effects, the nature of the commodity (perishable and non-perishable) and market expectations are the important components. In this manner, understanding the impact of one market on the other and job of each market fragment in price disclosure is the focal inquiry in market microstructural plan which has become an inevitably significant investigation issue among academicians, controllers and specialists in the similar way as it does in the market productivity, unpredictability, supporting viability and exchange openings.

The issue of price discovery is significant considering the relation between the diffusion of financial instruments and the increase in food commodities prices. In fact, although it is common knowledge that derivatives provide economic benefits, such as information dissemination, price discovery and efficient allocation of resources, there is a widespread public and regulatory perception that such financial instruments generate or exacerbate excessive speculation which, in turn, forces prices to be away from their fundamental value, with destabilizing effects on real markets (Gerety and Mulherin 1991, Fleming and Ostdiek 1999). Keeping in view the significance of data on prices in exchanges and in various markets for the benefit of producers and market functionaries, the present study will be a modest attempt in examining the supply behaviour and pricing of selected agricultural commodities in India. The present study will be led with the following specific objectives:

1. To study the seasonal behaviour of prices and arrivals of selected agricultural commodities,
2. To identify the determinants of pricing of selected agricultural commodities and,
3. To study the Exchange and Market prices in relationship with prices.

Chapter-2

REVIEW OF LITERATURE

Yang *et al.* (2001) inspected futures market for commodities i.e., storable and non-storable for value disclosure. It was found that the value disclosure work isn't misrepresented by resource storability, despite the fact that futures market forecasts might be one-sided by resource storability. It set up that futures market plays out a main errand in both of the products.

Asche and Guttormsen (2002) examined the lead lag relationship between spot and futures prices by testing for cointegration with the Engle and Granger methodology. This approach, although appealing for its simplicity, is problematic on at least two accounts. First, the approach is only valid given an exogeneity assumption, which is what one wants to test and second, given that there are several contracts with different times to expiration, bivariate specifications cannot capture all the relevant information. They showed that both problems can be avoided if the tests are carried out in a multivariate framework like the Johansen test. An empirical application was carried out on futures prices for gas oil. The findings of the study indicated that futures prices leads spot prices and that futures contracts with longer time to expiration leads contracts with shorter time to expiration.

Mckenzie and Holt (2002) tested market efficiency and unbiasedness in four agricultural commodity futures markets – live cattle, hogs, corn and soybean meal – using co-integration and error correction models with GQARCH-in-mean processes. They found that each market is unbiased in the long run, although cattle, hogs and corn futures markets exhibit short-run inefficiencies and pricing biases. Models for cattle and corn outperform futures prices in out-of-sample forecasting. Results also suggested short-run time-varying risk premiums in cattle and hog futures market

Kumar (2004) investigated into the futures market in Agricultural commodities in India. The results obtained from regressions for a sample of five commodities traded in six exchanges uncover that these futures trades neglect to find costs and give productive support against the risk emerging from price volatility.

Al-Saad and Moosa (2005) explored the idea of irregularity for month-to-month stock returns got from an overall list of the Kuwait Stock Exchange. The creators time series model with stochastic dummies for analyzing data. The outcomes uncover that irregularity is present however it is deterministic as suggested by the consistency of month-to-month occasional elements over the example time frame.

Sahi and Gurpreet (2006) considered the effect of start of exchanging futures on the flimsiness of the key commodities in India. The realistic outcomes of the examination suggested that with the introduction of futures trading the idea of unpredictability has not changed in the basic commodities. In any case, a debilitate outcome was set up from futures cost to spot in the event of few products. Furthermore, trial of Granger Causality results showed there is an upgrade in unpredictability of money value infer able from an eccentric lift in Futures movement.

Lui and Zhang (2006) investigated the value productivity procedure of futures and spot markets in China and set up a long-standing adjusted association which exists between two business sectors and bidirectional progression of data. The investigation demonstrated that futures market goes about as a helpful instrument of value advancement.

Easwaran and Ramasundaram (2008) in their examination on Whether Commodity Futures Market in Agriculture is Efficient in Price Discovery? The examination explored into the futures markets in farming products in India. The factual examination of information on value disclosure in an example of four farming items traded in futures exchanges demonstrated that value revelation doesn't happen in agrarian commodity futures market. The econometric examination of the connection between value return, profundity volume, market and instability has demonstrated that the market volume and profundity are not fundamentally impacted by the return and unpredictability of futures just as spot markets.

Roy (2008) broke down futures agreements of wheat in India. The examination found that futures market of wheat is finely connected with spot markets in India. The investigation found that there is causality in the two ways in the selected contracts during the examination time frame.

Baek and Koo (2009) examined the short and long-run impact of macroeconomic factors, such as agricultural commodity prices, premium costs and trade rates on the U.S. farm income using auto-regressive distributed lag approach. Results uncover that product costs and loan fees have been huge factors in impacting U.S. farm income in both the short and long haul. They likewise show that exchange rates play a crucial role in determining long-run conduct, however has little impact temporarily.

Singh (2010) studied price linkages in competing domestic commodity futures markets on MCX, NCDEX and NBOT for soya oil in India. He also examined the hedging efficiency of three domestic and one international exchange CBOT. He found that there is cointegration of futures prices of soya oil traded MCX, NCDEX and NBOT. This study also found the evidence of arbitrage opportunities across three exchanges. The domestic exchanges provide relatively less hedging efficiency than CBOT.

Hernandez and Torero (2010) investigates the unique connection between spot and futures prices of agricultural commodities. They first examined what the non-exchange and resource evaluating hypothesis needs to say about the connection between spot and futures markets. Then, using recent information for corn, wheat and soybeans, they performed Granger causality tests to exactly reveal the heading of data streams between spot and futures prices. Linear as well as nonlinear (nonparametric) causality tests were directed on both spot and futures returns and their instability. The outcomes show that spot prices are by and large found in futures markets. Specifically, we find that adjustments in futures prices lead changes in spot prices more frequently than the opposite. These discoveries likewise add to the discussion on elective instruments to address inordinate instability in grain markets. Their outcomes support, for example, the viability of implementing a global virtual reserve, recently proposed by von Braun and Torero (2008, 2009), to prevent disproportionate spikes in grain spot prices through signals and, if necessary, market assessment in the exchange of futures.

Pavabutr and Chaihetphon (2010) studied the gold futures contracts exchanged at the Multi Commodity Exchange of India (MCX) from 2003 to 2007 for value disclosure by using Vector Error Correction Model (VECM) which exhibit that futures costs of standard and scaled down agreements show the best approach to spot cost. The examination discoveries demonstrated that both the futures contracts uncover a more grounded influence over spot costs in the short and significant stretch.

Iyer and Pillai (2010) in their paper examined whether futures markets play a dominant role in the price discovery process. The rate of convergence of information from one market to another is analyzed to infer the efficiency of futures as an effective hedging tool. The study finds evidence for price discovery process happening in the futures market in five out of six commodities. However, the rate of convergence of information is slow, particularly in the non-expiration weeks.

Ali and Gupta (2011) analyzed the efficiency of agricultural commodity markets by assessing the relationships between futures prices and spot market prices of major agricultural commodities in India. The efficiency of the futures market for 12 agricultural commodities, traded at one of the largest commodity exchanges of India, i.e., National Commodity & Derivatives Exchange Ltd, were explored by using Johansen's cointegration analysis and Granger causality tests. Unit root test procedures such as Augmented Dickey-Fuller and non-parametric Phillips-Perron were initially applied to examine whether futures and spot prices are stationary or not. The hypothesis, that futures prices are unbiased predictors of spot prices were tested using econometric software package. The results of the study show that cointegration exists significantly in futures and spot prices for all the selected agricultural commodities except for wheat and rice. This suggest that there is a long-term relationship between futures and spot prices for most of the agricultural commodities like maize, chickpea, black lentil, pepper, castor seed, soybean and sugar. The causality test further distinguishes and categorizes the commodities based on direction of relationship between futures and spot prices. The analysis of short-term relationship by causality test indicates that futures markets have stronger ability to predict subsequent spot prices for chickpea, castor seed, soybean and sugar as compared to maize, black lentil and pepper, where bi-directional relationships exist in the short run. The results of this study are useful for various stakeholders active in agricultural commodities markets such as producers, traders, commission agents, commodity exchange participants, regulators and policy makers.

Mukherjee (2011) made an attempt to re-validate the impact of futures trading on agricultural commodity market in India. The daily price information in spot and futures markets, for a period of 7 years (2004 – 2010), for 9 major agricultural commodities, taken from different categories of Agri-products, were incorporated into various econometric models to test the concerned objective. The empirical findings significantly shows that comparative advantage of futures market in disseminating information, leading to a significant price discovery and risk management, that can again help to successfully develop the underlying commodity market in India. Therefore, instead of curbing the commodity futures market, it was suggested to strengthen the market structure to achieve the broader target.

Imai *et al.* (2011) examined the extent to which the production of different agricultural commodities, namely, maize, wheat, rice, fruit, vegetable and oilseeds, responds to price changes in selected Asian countries given the recent high and volatile agricultural prices. They analyzed a strong positive yield response to higher prices in a panel of 10 Asian countries. However, it was found that a considerable variation in the strength and speed of yield responses of these different commodities. They found that the yield response in the current period is strongest for oilseeds. The price of oil has a negative effect on yields of most of the commodities. For wheat, rice, vegetable and oilseeds, the yield responses weakened after 2000. The results of the study suggested that the analysis points to the potential of price policy in inducing a large supply of food grains given the high output elasticity of marketed supply.

Baldi *et al*. (2011) explored the long-run relationship among spot and futures prices for corn and soybeans, for the time frame January 2004 -September 2010. Cointegration methodology was applied within the sight of possibly obscure primary breaks in the commodity prices and at that point they studied the causality connections among spot and futures prices inside every particular sub-period distinguished, with the mean to investigate where changes in spot and futures prices start and how they spread. Observational appraisals feature the accompanying proof: I) breaks identify with occasions that have fundamentally influenced the market interest of corn and soybeans for food and energy purposes; ii) sub- periods therefore distinguished express various elements in the causal relationship between spot and futures prices and backing those numerous variables added to the 2007-2008 food price increase.

Reeve and Vigfusson (2011) discussed the theoretical relationship between spot and futures prices for commodities and evaluated the empirical forecasting performance of futures prices relative to some alternative benchmarks. The key results of their analysis were, that futures prices have generally outperformed a random walk forecast, but not by a large margin, while both futures and a random walk noticeably outperform a simple extrapolation of recent trends (a random walk with drift). Importantly, however, futures prices, on average, outperform a random walk by a considerable margin when there is a sizeable difference between spot and futures prices.

Srinivasan (2011) has analyzed Price Discovery and Volatility Spillovers in Indian Spot – Futures commodity market. Information from June 2005 to November 2010 of four product future lists and its comparing hidden spot files of MCX Mumbai were utilized in the examination. The VECM shows that item spot market assumes a prevailing job and fills in as powerful value disclosure vehicle, suggesting that there is a progression of data from spot to futures commodity market.

Varadi (2012) has conducted an investigation named "An evidence of speculation in Indian Commodity Market". Price volatility is affected by a few elements like market interest, overabundance liquidity and disposition of examiners and speculators. The examination has endeavoured to discover the effect of the above said factors in Indian commodity futures market and the outcomes show that hypothesis assumed crucial part in value unpredictability particularly during worldwide emergencies. Fortnightly information is accumulated from FMC month to month arrangement for MCX, NCDEDX and NMCEX for the time of 2006 – 2010 and utilized in the investigation.

Solanki and Dash (2012) have led an investigation on Commodity market behavior, price discovery and its factors. The examination considered 12 commodities for 2003 to 2011 and assessed long-term volatility of each commodity. Effect of expansion and volume on the costs of products was tried by GARCH model. The outcomes show that inflation had a significant effect on crude oil futures, volatility in gold, natural gas and pepper.

Chhajed *et al.* (2013) analyses the market behaviour and price discovery in Indian Agriculture Commodity Markets. The functioning of future market came under scrutiny during 2008–2009 due to price rise and the role of futures market in stabilizing spot prices was widely studied. The study considered average monthly spot and future prices of nine agriculture commodities *viz*. wheat, chana, soybean oil, jute, mentha oil, rubber, potato, crude palm oil and cardamom trading on MCX and NCDEX during 2009–2010. Granger causality test was used to test the price discovery, i.e., the effect of future market on spot market and vice-versa. The market behavior was studied with the help of backwardation and contango. The result of the study revealed that the price discovery mechanism is quite different for different commodities but it suggests that causality can be used in forecasting spot and futures prices. Most of the commodities showed bi-directional causality between spot and future prices. The contango and backwardation helps in identifying the hedging opportunities in the market.

Edward and Rao (2013) considered Price Discovery Process and Volatility spillover of Chilli Spot and Futures prices evidence from National Commodity and Derivative Exchange Ltd., The causality between Chilli Spot and Futures costs was analyzed by Granger causality test. Chilli Futures for April 1, 2006 to March 31, 2013 tried bi-co-integration models. The study reveals that, in long-run the spot and futures market are co-integrated and causality is existing between the markets. The causality discovered is unidirectional Chilli futures market gives guidance to farmers and the market is productive.

Joseph *et al*. (2014) examined the direction, strength and extent of causal relationship between futures and spot prices of Indian commodity markets using frequency domain approach of Breitung and Candelon (2006). Frequency domain analysis offers an effective alternative tool by examining the causality in frequency domain, whereas in traditional econometric causality analysis tools focus only on the time domain. Daily futures and spot price series on eight commodities from the Indian commodity exchanges (MCX and NCDEX) were examined for the period 3rd January, 2008 to 31st December, 2012. The results of frequency domain analysis suggest that there is a strong uni-directional relationship from futures to spot in almost all the selected commodities. This indicates that futures market has a powerful price discovery function in all the selected commodities; which in turn indicates the efficiency of Indian commodity futures market.

Soni (2014) studied the market efficiency, unbiasedness and the direction of causality among four agricultural commodity futures contracts for a forecasting horizon of 28 days, 56 days and 84 days which are traded at National Commodity and Derivatives Exchange Ltd. To analyse the efficiency of futures market in Indian scenario, he focused on maize, chickpea, soybean and wheat which are among the most important agricultural commodities traded in India. Augmented Dickey-Fuller test and nonparametric Phillips-Perron approaches were used to examine the stationarity of all futures and spot price series. After testing the presence of cointegration in futures and spot series using Johansen's Cointegration approach, the joint restrictions of $\beta 0=0$, $\beta 1=1$ and $\beta 1=1$ on the cointegrating vectors were imposed to test whether the futures price is an unbiased predictor of spot at contract maturity. In the next step, linear Toda and Yamamoto (1995) and the nonparametric Diks and Panchenko (2005) causality tests were applied to examine the direction of causality. Finally, nonlinear test was applied on the vector error correction model (VECM) residuals to investigate whether any remaining causality is strictly nonlinear in nature. The results of cointegration tests between futures and spot prices of the selected agricultural commodities indicated a long-term relationship do exist in three out of four futures contracts. However, the Wald tests results on the cointegrating vectors indicate markets as inefficient and biased. Further, analysis of short-term relationship using alternate tests of causality do not give consistent results for same commodity series indicating that results may vary due to alternate measures and specifications. Finally, if we consider the results of Diks-Panchenko test on the filtered VECM-residuals, results provide evidence that if cointegration is taken into account; neither spot nor future leads or lags the other consistently. The results were based on the sample of four agricultural futures commodity contracts. It was suggested that the study can be extended to a larger sample of contracts and relative efficiency of each contract can be explored.

Ding *et al.* (2014) explored the causal relationship between the net financial position and the crude oil price by using three types of Granger non-causality tests: the classical Granger non-causality test, a robust Granger non-causality test and a Granger non-causality test in quantiles. The empirical results provide some evidence of causality from the net financial position to the spot price of crude oil. In addition, futures prices serve as a transmission mechanism underlying the causal relationship between the net financial position and the crude oil price.

Nicolau and Palomba (2015) analyzed the dynamic relationship between spot and futures prices and to establish if there is the possibility of a valid "period by period" prediction of the futures price conditional on the prediction of the spot price and vice-versa. The empirical analysis was conducted on the two most important energy commodities, crude oil and natural gas and on gold, the most important commodity used for risk hedging and investment during financial turmoil, paying particular attention to the exogeneity issue. A battery of recursive bivariate VAR models over a sample of daily spot and futures prices, ranging from January 1997 to May 2014 were estimated. The results of the study show that some interactions between spot and futures prices clearly exist and they mainly depend on commodity type and futures contracts maturity. In case of the natural gas strong exogeneity operates, while in the case of crude oil, where the exogeneity is generally weak and depends on the contract maturity. On the gold market the results show no possibility of a valid forecasting between spot and futures prices.

Singh and Singh (2015) investigated the Chana futures market for efficiency and seasonality. The study was conducted for the time-frame of ten years from 2005 to 2014. Data on spot and futures prices was analyzed for efficiency using Johansen cointegration approach and seasonality effect using dummy variable in regression model. Analysis of the available data suggested that Chana futures market is efficient although it is affected by the seasonality pattern of the crop.

Jena (2016) conducted an investigation named "Financialization of Commodity Market in India: A closer look at the evidence". The impact of financialization of price risk and price volatility of Indian commodities market has been studied by using time series techniques. The investigation uncovered that the commodity price index is identified with stock index price and causality test indicated that commodity prices are Granger causing the stock prices in India.

Arismendi *et al.* (2016) analyzed the importance of seasonal behavior in the volatility for the pricing of commodity options. They proposed a seasonally varying long-run mean variance process that is capable of capturing empirically observed patterns. Semi-closed-form option valuation formulas were derived. The impact of the proposed Seasonal Stochastic Volatility Model on the pricing accuracy of natural gas futures options traded at the New York Mercantile Exchange (NYMEX) and corn futures options traded at the Chicago Board of Trade (CBOT) were empirically studied. The results of the study demonstrate that allowing stochastic volatility to fluctuate seasonally significantly reduces pricing errors for these contracts.

Raghavendra *et al*. (2016) empirically examined the market which reacts first in India by assessing the relationship between spot and future prices of agricultural commodities such as Soya bean, Chana, Maize, Cumin and Turmeric for a period from January 2010 to March 2015 traded in NCDEX. The results of the study suggest the existence of long-run equilibrium relationships between futures and spot prices for all the 5 agricultural commodities that were taken for this study. Regression model pertaining to Lead-Lag relationship between Spot and Future markets suggests that for the commodities Maize, Cumin and Turmeric, both the spot and future markets price assumes the main part in the value revelation cycle and said to be educationally proficient and responds all the more rapidly to one another.

Gilbert *et al*. (2017) systematically measures seasonal price gaps at 193 markets for 13 food commodities in seven African countries. It shows that the commonly used dummy variable or moving average deviation methods to estimate the seasonal gap can yield substantial upward bias. This can be partially circumvented using trigonometric and saw-tooth models, which are more parsimonious. Among staple crops, seasonality is highest for maize (33 percent on average) and lowest for rice (16½ percent). This is two and a half to three times larger than in the international reference markets. It was revealed that seasonality varies substantially across market places but maize is the only crop in which there are important systematic country effects. It was also observed that in Malawi, where maize is the main staple, emerges as exhibiting the most acute seasonal differences. It was suggested that for reaching the Sustainable Development Goal of Zero Hunger renewed policy attention to seasonality in food prices and consumption is required.

Quintino *et al*. (2017) investigated and analyzed the relationship between ethanol spot and futures prices in Brazil. Engle and Granger co-integration approach was adopted. Also, the information share method proposed by Hasbrouck was considered in order to examine the market efficiency in price discovery and information transmission. The results of the study show that although the futures market is efficient in price discovery and information transmission, the cash market leads the long-run price discovery process. This suggests that the underlying cause of the dominance of the available market over the futures market can be attributed to the market's relative concentration in wholesale ethanol distribution due to the formation of marketing pools by the ethanol mills, as well as the small number of distributors that control a significant portion of the market share.

Dimpfl *et al*. (2017) studied the relationship between spot and futures prices of corn, wheat, soybeans, soybean meal and oil, feeder and live cattle, as well as lean hogs to test which markets lead price discovery in these commodities. Using a recently developed unique information share evidences were found that the prices of these commodities are almost uniquely formed in the spot market. The market for futures contracts contributes less than 10% to price discovery (in the Hasbrouck sense). The results were interpreted as evidence against adverse effects of futures speculation on commodity prices in the long run.

Babshetti and Basanna (2018) examined the existence of convergence between spot and futures prices of five selected agricultural commodities namely, Chana, cumin, pepper, maize and chili during 2011 - 2017. The study aimed at assessing the scope for arbitrage profit. The negative spread was observed in December 2015 and June 2016 Chana futures contracts. In case of cumin, the spot prices were greater than futures at some point of time during the contract period of April 2010 and December 2010 and April and September 2011 contracts. In case of pepper futures, the backwardation was observed in July 2010 and July 2011 expiration, thereby providing scope for arbitrage profit. In December 2011 maize contract had a negative basis in the beginning; whereas, December 2013 maize contract had a negative basis throughout the contract period. In case of chili, the spot prices were higher than the futures prices in April 2012, June 2013 and September 2015 futures contracts. The study revealed the presence of scope for arbitrage profit in these contracts. The study also found the presence of all three types of market patterns in one or the other selected contracts.

Kirithiga *et al*. (2018) in their study aims to find out whether any causality exists among the commodity spot and futures in India. Commodities futures traded in two major Indian bourses MCX and NCDEX were tested over a period of 10 years between 2006 and 2015. After analysis, they found a causal relationship through Granger's causality that evidenced the integration of futures and spot markets with a unidirectional information flow among them. The results of the study suggested that Government and policy makers need to undertake measures to monitor and control excessive speculation in the futures market, effective implementation of which would help in avoiding inflationary pressures on commodity prices in the spot market.

Manogna and Mishra (2020) investigated empirically the price discovery and volatility spillover in Indian agriculture spot and futures commodity markets. The study used Granger causality, vector error correction model (VECM) and exponential generalized autoregressive conditional heteroskedasticity (EGARCH) to examines the price discovery and spillover effects for nine most liquid agricultural commodities in spot and futures markets traded on National Commodity and Derivatives Exchange (NCDEX). The VECM results showed that price discovery exists in all the nine commodities with futures market leading the spot in case of six commodities, namely soybean seed, coriander, turmeric, castor seed, guar seed and chana. Whereas in case of three commodities (cotton seed, rape mustard seed and Cumin), price discovery takes place in the spot market. The Granger causality tests indicated that futures markets have stronger ability to predict spot prices. Supporting these, the results from EGARCH volatility test revealed that there exist mutual spillover effects on futures and spot markets. It was inferred that futures market is more efficient in price discovery of agricultural commodities in India. It was suggested that the results of the study can help policymakers to design futures contracts to improve the efficiency of the agricultural commodity derivatives market.

Tonin *et al*. (2020) investigated the dynamics of volatility and conditional correlations between corn and soybean prices in the spot and futures markets. Dynamic conditional correlation specifications with a bivariate GARCH model was employed, with data for Brazilian and U.S. markets from the period 2004–2017, during which numerous structural changes and severe climate phenomena occurred. Highest correlations and evidence of spillovers between the corn and soybean spot markets were found in the spot and futures markets. It was also found that the financial crisis has significantly affected the relationship between the corn and soybean markets, also in periods of increased conditional correlation between the soybean and corn markets, there is an increase in the optimal hedge ratio for risk management strategies involving corn futures contracts at B3 and Chicago Mercantile Exchange.

Samak *et al*. (2020) empirically investigated the direction of relationship between food spot and futures prices using different methodologies so as to resolve the debate. They conducted linear and non-linear Granger causality tests along with cointegration and error correction model and concluded with mixed findings. Specifically, linear and nonlinear Granger causality tests found evidence that food futures prices cause food spot prices and suggested that food futures markets lead the price discovery process and hence, the direction of information flows goes from food futures markets to food spot markets and accordingly, any price volatilities in futures markets lead to price volatilities in spot markets. In contrast, the cointegration and error correction model found evidence that food spot prices cause food futures prices and suggested that food spot markets lead the price discovery process and hence, the direction of information flows goes from food spot markets to food futures markets and accordingly any price volatilities in food spot markets lead to price volatilities in futures markets. Based on these differences in the obtained results, they suggested that the cointegration and error correction model is preferable since it provides a more formal framework for examining the short-run dynamics and testing for the equilibrium relationship among economic variables. It was also suggested that special attention to alternative instruments, such as the implementation of a global virtual reserve, should be highlighted so as to minimize speculative attacks and avoid excessive spikes of prices in spot and futures markets. This implies the importance of adopting the possible protectionist measures by developing countries in order to hedge against the negative reflections of global food price volatility.

Pradhan *et al*. (2020) examined the lead-lag relationship between spot and futures prices in the Indian commodity market for the period 2009 to 2020. The

ARDL bounds-testing technique was used to explore the long-run relationship between these two prices. A VECM was then used to reveal the nature of Granger causality between the two. The results indicated a long-run equilibrium relationship between the spot and futures prices of these six commodities. The causality analysis reveals unidirectional causality in the long run from the spot to the futures price for aluminium and copper and both bidirectional and unidirectional causality in the short run between the two prices for aluminium, copper, gold and silver.

Singh *et al*. (2020) made an attempt to examine the price discovery relationship of future and spot prices of five agricultural commodities, namely cardamom, crude palm oil, cotton, mentha oil and kapas, during the period 2011–2019. Johansen's co-integration test, vector error correction model (VECM) and Granger causality block exogeneity test were employed for the study. It was found that price discovery process is established for agricultural commodities under consideration. Future prices act as a leader in achieving long-run equilibrium for all commodities except cardamom. Causality was significantly reported for all commodities, as bidirectional causality runs between the prices. The study suggests that Forward Market Commission should be empowered more to control and regulate the market, which will ensure the efficient market situations in these commodities' market. Attempt was also made to evaluate price discovery process in agricultural commodities market during post sub-prime crisis period, which was ignored by majority of researchers.

Bodhanwala *et al*. (2020) investigated the impact of structural change on the progression of data between the spot and futures market of agricultural commodities and select macro-economic factors. The volatility in agriculture commodity prices was concentrated concerning three prevailing macro-economic financial components—development in rough value which fills in as a contribution to farming area, development in INR/USD conversion standard and development in Sensex which is considered as an indicator of interest in India.

The non-linear co-integration and causality test was utilized to comprehend the bearing of causality in volatility of items and effect of large-scale monetary components. It was seen that the agriculture commodities spot and futures prices are to be co-integrated with crude, forex and Sensex for larger part of the break time frames and it was discovered that futures market played a leading role in the price discovery function and information processing. Blended consequences of impact of exchange rate, Sensex and crude on agriculture prices in various sub-periods were additionally noticed.

Chapter-3

MATERIALS AND METHODS

The reliability, precision and validity of the research findings of any investigation depend upon the selection of appropriate techniques. This chapter cogently elaborates the methodology that includes selection of commodities, sources of data and analytical framework followed in the study. The present study on "Supply Behaviour and Pricing of Selected Agricultural Commodities in India: Comparative Investigation into Exchange and Market pricing system" was undertaken during the year 2020 under the ambit of School of Agricultural Economics & HBM, SKUAST-Kashmir. The methodology followed in the study is detailed below under various sections.

3.1 Selection of the commodities

The present study pertains to agricultural commodity sector in India as a whole and intends to examine the Supply Behaviour and Pricing of Agricultural Commodities in India using the data from Exchanges and Markets prevailing in India. The selection of the agricultural commodities for the present study includes Castor seeds, Coriander, Soybean, Cumin and Turmeric. The markets selected for Castor seeds, Coriander, Soybean, Cumin and Turmeric were Deesa, Kota, Akola, Unjha and Nizamabad, respectively. The selection of the markets was as per the volume of trade in the selected market.

3.2 Brief description of the selected agricultural commodities

1. Castor seed

Castor is an important non-edible oilseed, basically a cash crop, cultivated around the world owing to the commercial importance of its oil. It is reported to have originated in the tropical belt of both India and Africa. Castor is an annual crop. It requires moderately high temperatures with low humidity throughout the growing season to produce maximum yields. Time of sowing depends on the onset of monsoon. Generally, Castor seed planting takes place during July-Aug. Under certain circumstances, it can be sown even during September also. Harvesting starts in December or January and extends till April. Gujarat is the largest Castor producing state followed by Andhra Pradesh and Rajasthan.

Exchange Specifications

Trading in Castor Seed (CASTOR) Futures contract may be conducted under such terms and conditions as specified in the, Bylaws, Rules and Regulations of the Exchange and as per the circulars and notifications issued by the Exchange thereunder or the Securities and Exchange Board of India (SEBI) from time to time. The unit of trading shall be 5 MT. Bids and offers may be accepted in lots of 5 MT or in multiples thereof. Castor Seed (small seed) with the specifications as; Oil content 47% Min., Fotri (Husk) and damaged Seeds 3.5 % Max., Sand, Silica and Stones 1% Max., Moisture content 4.5 % Max.

Packaging

Castor seed should be delivered in 75 Kg gross weight basis and maximum number of bags in a lot of 5 MT should not be more than 68 bags in clean, dry, sound, single, new or once used un-mended Twill/Jute bags in merchantable condition without patches, or any other accepted industry standard material with the mouth of the bag stitched disallowing sweating/spilling and not having previously used for cement bagging.

Charges

All charges and costs payable at the approved warehouse towards delivery of Castor seed including sampling, grading, weighing, handling charges, storage etc. from the date of receipt into approved warehouse up-to date of pay in & settlement shall be paid by the seller.

Duties & levies

Stamp duty is payable on all contract notes issued as may be applicable in the State from where the contract note is issued or as per The Stamp Act of the State in which such Contract note is received by the client, if such client is located in other state.

Taxes

GST shall be payable by the members on the gross amount charged by them, from their clients on account of dealing in commodities.

2. Coriander

Coriander is one of the most widely used spices in the world. It is one of those herbs which have all their parts edible; however, the commercial parts of the plant are its leaf and seed. Coriander is grown as a rabi season crop in India. The sowing period is from October to December. The crop gets ready for harvest in about 90 to 110 days depending upon the varieties and growing season. Harvesting generally takes place during February and April. Madhya Pradesh, Rajasthan and Gujarat are the important Coriander producing states in India.

Exchange Specifications

Coriander(Indian origin) has necessarily to be machine cleaned, moisture between(Min)8%and(Max)9% with 1:1 discount, foreign matter 0.00 –0.90 % Max; damaged & discoloured seeds– Max 1.90%; shrivelled seeds- basis 1%

acceptable up to 1.5 % with 1:1 discount ; weevil seeds – Max 0.5% ; Coriander splits (Dal) – Basis 5% and acceptable up to 9.50% with 1:0.5 discount ; Live infestation – not allowed (foreign matter includes dust, dirt, stones, lumps, earth, chaff, stalk, stem/straw, edible seeds of fruits other than Coriander)

Packaging

Coriander delivered shall be packed in new sound jute bags or once used, sound sugar bags only, in merchantable condition. The packaging will be on 40 Kg gross basis.

Charges

All charges and costs payable at the approved warehouse towards delivery of Coriander including sampling, grading, weighing, handling charges, storage etc. up to the date of electronic credit of the holding of Coriander into the buyer's repository account shall be payable by the seller.

Duties & levies

Stamp duty is payable on all contract notes issued as may be applicable in the State from where the contract note is issued or as per The Stamp Act of the

State in which such Contract note is received by the client, if such client is located in other state.

Taxes

GST shall be payable by the members on the gross amount charged by them, from their clients on account of dealing in commodities.

3. Soybean

Soybean is one of the largest oilseeds grown in India and a highly liquid derivatives contract both in India and international markets. In India, Soybean is grown exclusively in the Kharif season. The harvesting commences from September, with Maharashtra reporting the earliest arrivals. October and November are the peak arrival months.

Exchange Specifications

Quality delivery with variation shall be acceptable with discount as under: Foreign Matter-from 2-4% accepted at discount of 1:1, from 4-5% accepted with a discount of 1:2. Above 5% rejected (The term 'foreign matter' would, in-general, mean anything other than Soy Bean e.g., sand, silica, pebbles, stalks and other seeds). damaged seed: from 2-5% accepted at 2:1. Above 5% rejected; Green

Seed - Above 7% rejected, free from non-edible seeds such as Mahua, Castor and Neem and any toxic substances. Should be free from any foul odour and live infestation.

Packaging

Soybean should be delivered in 50 kg, 91 Kg or 100 kg gross weight basis in new or sound and un-mended Jute bags without any patches.

Charges

All charges and costs payable at the approved warehouse towards delivery of Soybean including sampling, grading, weighing, handling charges; storage etc from the date of receipt into approved warehouse up to date of pay-in & settlement shall be paid by the seller.

Duties & levies

Stamp duty is payable on all contract notes issued as may be applicable in the State from where the contract note is issued or as per The Stamp Act of the State in which such Contract, note is received by the client, if such client is located in other state.

Taxes

GST shall be payable by the members on the gross amount charged by them, from their clients on account of dealing in commodities.

4. Cumin

Cumin seed commonly known as Cumin is the dried, white fruit with greyish brown colour of a small slender annual herb. It had a major role as a flavoring, spice and medicinal uses throughout history. In India, Cumin is grown as a Rabi crop. Sowing is done during October to December while harvesting starts from February onwards. It requires less water and colder for its better growth with ideal temperature of 25 to 30 degree. Cumin crop is highly sensitive to rain/ high humidity and if rain occurs during harvesting time, quality of the

Cumin gets badly affected (it turns black). The major producing states are Gujarat and Rajasthan in India.

Exchange Specifications

Cumin of Indian origin with the following specifications:

Foreign Matter - 1.0 % Max, seeds with stalks 8.0 % Max; damaged, discoloured, shrivelled and immature seeds - 4.5% Max, insect damaged matter should not be more than 0.5%, Test Weight (on count basis) Maximum 300 seeds per gram, Moisture 8% Basis, 9.5% Maximum. Foreign matter includes anything other than Cumin seeds e.g., sand, silica, pebbles and other edible/non edible seeds.

Packaging

Cumin delivered shall be packed in new Jute bags (Twill Bag) in merchantable condition with the mouth of the bag machine stitched disallowing sweating / spilling. The packaging of Cumin should be in standard bags of 60 Kg net weight only. Weight deduction per bag for calculation of net weight will be 1 Kg.

Charges

All charges and costs payable at the approved warehouse towards delivery of Cumin including sampling, grading, weighing, handling charges, storage etc. from the date of receipt into approved warehouse up to the date of pay in & settlement shall be paid by the seller.

Duties & levies

Stamp duty is payable on all contract notes issued as may be applicable in the State from where the contract note is issued or as per The Stamp Act of the State in which such Contract Note is received by the client, if such client is located in other state

Taxes

GST shall be payable by the members on the gross amount charged by them, from their clients on account of dealing in commodities.

5. Turmeric

Turmeric is one of the most important spices as well as medicinal agent and is grown during Kharif season in India. The commercial part of Turmeric is rhizome or underground stem. It requires a hot and moist climate and hence can be grown on different types of soil under irrigated and rainfall conditions and has crop duration of 7-9 months. Sowing period varies from June to August while harvesting takes place between Dec-March. Important producing states are Telangana andhra Pradesh, Tamil Nadu and Maharashtra.

Exchange Specifications

Unpolished turmeric fingers with the following specifications as the basis unpolished turmeric fingers; inferior quality turmeric such as Chora/atthu finger, khotagatha and markha should not be more than 2.25%; Length - broken fingers /those less than 15mm should not be more than 3.0%. and those less than or equal to 3 cm in length should not be more than 15%; damage due to moisture (i.e., Lokhandi) or over boiling (i.e., Kadh) should not be more than 1.2%; unboiled or less boiled (Gajarthod) turmeric should not be more than 0.3%; bhusa, chaff dirt, earth clods and stones should not be more than 0.75%; bulbs should not be more than 3%; moisture - 12% max. Turmeric should be free from and should not be artificially coloured with dyes or chemicals.

Packaging

Turmeric delivered shall be packed in joint B-Twill bags of accepted industry standard material and in merchantable condition with no spilling of contents and with the mouth of the bag stitched disallowing sweating / spilling. Inside marking of bags with FCI shall be allowed. Poultry /cattle feed bags usage will lead to rejection of such lots. The packaging of turmeric should be in standard bags of 50/60/70 Kg. Net weight of the bag should ideally be 1 Kg for 60/70 Kg bags and 600 gms. for 50 Kg bag.

Charges

All charges and costs payable at the approved warehouse towards delivery of Turmeric including sampling, grading, weighing, handling charges, storage etc. from the date of receipt into approved warehouse up to the date of pay in &

settlement shall be paid by the seller.

Duties & levies

Stamp duty is payable on all contract notes issued as may be applicable in the State from where the contract note is issued or as per The Stamp Act of the State in which such Contract Note is received by the client, if such client is located in other state.

Taxes

GST shall be payable by the members on the gross amount charged by them, from their clients on account of dealing in commodities.

3.3 Sources of data

Data required for the study was drawn from secondary sources. The secondary sources include data from NCDEX (National Commodity Derivative Exchange), SEBI (Securities and Exchange Board of India), and the data from the CMIE (Centre for Monitoring Indian Economy) database. The daily data on prices and arrivals for all the selected agricultural commodities was collected from the year 2004-2020.

3.4 Analytical framework

In accordance with the objectives and data availability for the present study, following analytical tools were employed for the analysis/interpretation of data.

3.5 Statistical tool

Following statistical/mathematical tools were employed for analysis of data.

3.5.1 Examination of growth rate

To examine the growth of prices and arrivals of selected agricultural commodities over the years, Compound Growth rate (CGR) was employed.

$$Y = ab^t$$

Where Y, the variable for which growth rate is calculated i.e., prices, arrivals

t=time variable taking 1, 2, 3……., n.

a=intercept

b=regression co-efficient of "Y" on t.

Exponential equation can be expressed in log form

$$\text{Log}Y = \text{Log}a + t\text{Log}b$$

Or

$$\text{Ln } Y = \alpha + \beta T$$

Where,

Y=time series data of price and arrival

T= trend term

α= constant coefficient

β= slope coefficient measure relative change in Y for a given absolute change in explanatory variable T. If we multiply the relative change in Y by 100, we will get percentage change or growth rate in Y for absolute change in variable T,

Compound Growth Rate (CGR) can be calculated by following formula

$$\text{CGR\%} = (\text{Antilog } \beta - 1) \times 100$$

CGR will be estimated by applying Ordinary Least Square (OLS) method. The t-test will be performed to test the significance of 'β".

3.5.2 Seasonality analysis

Analytical tool Moving Average Method-Components of Time Series Analysis the variation within a year is called seasonal variation. The seasonal variations are due to several factors like climate; production cycle of the crop, custom, climate etc. The seasonal variation can be estimated using moving average method, harmonic method. The seasonality in prices and arrivals of selected agricultural commodities over the year is calculated by using moving average method. To study the seasonal indices computed by simple moving average method developed (Acharya *et al*., 1995). Calculated through following steps;

1. Express price of each month as percentage of average price for the concerned year.
2. Work out the average (over years) of percentage for each month computed in (1)
3. Calculate the sum of 12-month averages(s) worked out in (b) and multiply the average of each month by the correction factors (k=1200/s) to make total 1200 or average 100.Seasonal indices of price and arrival of selected agricultural commodities can be worked out separately with ratio to moving average method as suggested (Godara *et al*., 2006; William *et al*., 1998).

$$\text{Seasonal Index (prices)} = \frac{\text{Actual average prices for the month}}{\text{Moving average price for the month}} \times 100$$

3.5.3 Stationarity test and cointegration

Time series data are said to be random or stochastic process. A stochastic process is said to be stationary if its mean and variance are constant over time and the value of the covariance between the two periods depends only on the distance or gap or lag between the two time periods and not the actual time with which the covariance is computed. To check the stationarity of the data Augmented-Dickey Fuller test will be employed. The testing procedure for the ADF test is the same as for the Dickey–Fuller test but it is applied to the model

$$\Delta y_t = \alpha + \rho y_{t-1} + \sum \beta_j \Delta y_{t-j} + \mu_t$$

Where α is a constant, β the coefficient on a time trend and ρ the lag order of the autoregressive process, Imposing the constraints $\alpha = 0$ and $\beta = 0$ corresponds to modelling a random walk and using the constraint $\beta = 0$ corresponds to modelling a random walk with a drift.

Given that the Futures prices and Mandi spot prices are integrated of same order, the Johansen cointegration tests proposed by Johansen and Juselius (1990) can be employed. The long- run relationship between the futures prices and mandi spot prices of the commodities is studied using cointegration technique. As suggested by Johansen (1988), two statistical methods, namely trace test and maximum eigen value test, are used to test the null hypothesis that there is at most r cointegrating vectors. The null hypothesis is stated as the rank of the coefficient matrix: π, is at most r, for r = 0, 1,...n -1. The two tests are represented as follows:

$$\lambda_{trace} = -T \sum_{i=r+1}^{n} ln\,(1 - \hat{\lambda}_i)$$

$$\lambda_{max} = T\,ln(1 - \hat{\lambda}_{t+1})$$

Where $\hat{\lambda}_i \dots \hat{\lambda}_r$ are the r largest squared canonical correlations between the residuals obtained by regressing the Δy_t and Δy_{t-1}. If r = 0, null hypothesis in trace statistic cannot be rejected, we will conclude that there is no cointegration. Whereas, if r = 1, null hypothesis for max eigen test is not rejected and r = 0 is rejected, we would conclude that a cointegration relationship exists. Cointegration is a necessary condition for the market to be efficient.

3.5.4 Estimation of Price Trend

To estimate the trend in the prices of the selected commodities, parametric, Non-parametric and Semi-parametric regression models were employed.

Parametric model

A proper parametric regression model was employed to check the impact of various factors, keeping prices as the dependent variable. The basic model takes the form:

$$P_t = f(Ar_t, Pr_t, Are_t, Y_t, I_t, E_t, S_t, D_I, D_R, D_E, D_{tr} \ldots U_t)$$

Where,

P_t	=	Prices at time t,
Ar_t	=	Arrivals at time t,
Pr_t	=	Production at time t,
Are_t	=	Area at time t,
Y_t	=	Yield at time t,
I_t	=	Imports at time t,
E_t	=	Exports at time t,
S_t	=	Seasonality at time t,
D_I	=	Dummy variable for infrastructure,
D_R	=	Dummy variable for road,
D_E	=	Dummy variable for electricity and
D_{tr}	=	Dummy variable for transport
U_t	=	Error term

The analysis of parametric test for different commodities was performed using econometric software Rstudio.

Non-parametric and Semi-parametric model

The model considered here is of the form:

$$Y_i = m(X_i) + E_i, X_i = \frac{i}{n}, i = 1,2, \ldots$$

Where, Y_i is observation of i^{th} time point, $m(.)$is trend function which is assumed to be smooth and$E_i$are random errors with mean zero and finite variance. Since there is no assumption of parametric form of function $m(.)$ This approach is flexible and robust to deviations from an assumed model form. To obtain an estimate of the mean response value at a point X, most of the observations having predictor values closer to the target value X. The averaging is done in neighbourhoods around target value. The main decision to be made in any of the smoothing techniques is to fix the size of neighbourhood which is typically expressed in terms of an adjustable smoothing parameter or bandwidth. Intuitively, large neighbourhoods will provide an estimate with low variance but potentially high bias and conversely for small neighbourhoods. Lowes's regression, introduced by Cleveland (1979), is obtained on the basis of the data points around it within a band of certain width. The point X_i is the midpoint of the band. The data points within the band are assigned weights in a way so that X_i has the highest weight. The weights for the other data points decline with their distance from X_i according to a weight function. The weighted least squares method is used to find the fitted value corresponding to X_i, which is taken as the smoothed value. The procedure is repeated for all the data points. The spline method of estimation makes use of the penalized least squares method (Simonoff, 2012), which balances the fitting of the data closely. The objective is to estimate m by means of a function that fits the data well and is as smooth as possible. A measure of smoothness of m is the integral of the square of its second derivative as;

$$\sum_{i=1}^{n}(Y_i - m(x_i))^2 + \lambda\int_a^b (m''(x))^2\,dx$$

Where λ > 0 is a fixed constant x_i□[a, b], i□1, 2...n

The first term is the sum of squares of the residuals; it provides a measure of how well the function m fits the data. The integral of the above equation is a measure for the m. The function which are highly curved will result in a large value of the integral; straight lines result in the integral being zero. The roughness penalty λ, controls the emphasis which one wishes to place on smoothness. By increasing the value of λ, one places more emphasis on smoothness; as λ becomes large the function approaches a straight line. On the other hand, a small value of λ emphasizes the fit of m to the data points: as λ approaches a function that interpolates the data points. The analysis for different commodities was performed using econometric software SAS version 9.3.

3.5.5 Granger Causality test

Granger causality test has been used to analyze the direction and causal relations between futures and Mandi spot prices of major agricultural commodities. The Granger (1969) approach predicts how much of the current value of one variable can be explained by past values of other variable and then tries to see whether adding lagged values of prior variable can improve the explanation. For instance, Y is said to be Granger-caused by X if X helps in the prediction of Y, or equivalently if the coefficients on the lagged X is statistically significant. Specifically, Y_t is causing X_t if some coefficient, ai, is non-zero in the following equation:

$$X_t = c_0 + \sum_{i=1}^{p} a_i Y_{t-1} + \sum_{j=1}^{p} b_j X_{t-j} + \varepsilon_t$$

A time series, Y_t, causes another time series, X_t, if the current value of X_t can be predicted better by using past values of Y_t than by not doing so:

$$Y_t = \gamma_0 + \sum_{i=1}^{p} \alpha_i X_{t-1} + \sum_{j=1}^{p} \beta_j Y_{t-j} + \mu_t$$

where p is the number of lags used for the variable. The regression equations (1) and (2) test the existence of short-term relationship between the variables X and Y. Moreover, if both futures and spot prices are cointegrated, then causality must exist in uni-directional or bi-directional. The test for causality is based on an F-statistics, which tests whether lagged information on a variable Y provides any statistically significant information about a variable X in the presence of lagged X. The F-statistic is given by:

$$F_1 = \frac{(SSE_0 - SSE_1)/p}{SSE_1/(T - 2p - 1)}$$

where SSE_0 and SSE_1 are the sum of squares of residuals, p is the number of lags and T is the number of observations. It is important to note that the statement "X Granger causes Y" does not imply that Y is the effect or the result of X. This implies that the Granger causality measures precedence and information content but does not by itself indicate causality in the true sense. The analysis of causality tests for different commodities was performed using econometric software Eviews Version 11.

Chapter-4

EXPERIMENTAL FINDINGS

4.1 Descriptive statistics

The Mandi spot and exchange futures prices for five agricultural commodities reveal that they are moving together over the period of time and hence seem to be cointegrated. These commodities show different trends with most of them exhibiting positive price trend in recent years (Table 1). The descriptive statistics for Mandi spot and exchange futures prices, such as mean, standard deviation, skewness, kurtosis and coefficient of variation (CV) along with total number of observations presented in the (Table 1) reveal that the futures price is higher than the Mandi spot price in all the commodities except castor seed. The highest Mean futures price was seen in case of Cumin (₹13053.42) followed by Turmeric (₹5862.55) and lowest in case of Castor seed (₹2834.99) respectively. Consolidation of information for the producers could be expected to have brought about the gap between the acknowledgment of mandi spot prices and declaration of exchange futures price. A highest CV of (63.83%) was observed in futures price in castor seed reveals its dispersed behaviour compared to mandi spot price (34.65%). The overall analysis of the data presented in (Table 1) concludes that except for Coriander and turmeric, all other commodities were either moderately skewed or symmetric around their respective means which reveals that futures market played a leading role in the price discovery function and information processing.

Table 1: Summary statistics of Mandi spot and Exchange Futures prices of the commodities

Commodity	Price	Total observations	Mean	SD	Minimum	Maximum	Skewness	Kurtosis	CV%
Castor seed	Mandi prices	199	3052.7	1057.7	1253.4	5119.2	-0.15	-1.024	34.65
	Futures prices		2834.99	1809.73	281.03	5775.1	-0.38	-1.41	63.83
Coriander	Mandi prices	199	4704.8	2027.29	1771.4	9770.5	0.502	-0.39	43.09
	Futures prices		5588.29	2196.54	2716.82	12528.91	1.42	1.52	39.31
Soybean	Mandi prices	199	2552.49	898.41	1067.60	4281.70	-0.10	-1.32	35.20
	Futures prices		2729.09	959.94	1145.44	4620.68	-0.12	-1.27	35.17
Turmeric	Mandi prices	199	5631.86	2771.79	1912.60	15284.80	1.06	1.69	49.22
	Futures prices		5862.55	2871.74	1673.00	14859.95	0.79	0.86	48.98
Cumin	Mandi prices	199	11469.61	3344.18	5125.60	18323.00	-0.12	-0.91	29.16
	Futures prices		13053.42	3785.75	5598.25	21518.5	-0.20	-0.68	29.00

Note: *SD indicates standard deviation, CV indicates coefficient of variation*

4.2 Examination of growth in the prices and arrivals of selected commodities

The behaviour of prices in response to arrivals of various commodities has remained an area of interest to study with the researchers over a period of time, especially with those agricultural commodities which have a lot of export potential. To study this behaviour Compound growth rate (CGR) was computed for the selected/ identified agricultural commodities for both prices and arrivals. The results presented in (Table 2) reveal positive and significant growth rate in prices and arrivals of agricultural commodities with Cumin showing the highest growth rate of (9.87%) in arrivals followed by Turmeric (9.05%) and the lowest in Coriander (5.06%) as against the prices where it showed all together a different scenario with highest in case of Coriander (7.55%) followed by Soybean (7.24%) and lowest in Cumin with (5.69%) respectively.

Table 2: Growth rate of prices and arrivals of selected agricultural commodities

Item	Particular	Study Period (Jan 2004-July 2020)				
		Castor seed	**Coriander**	**Soybean**	**Cumin**	**Turmeric**
Prices	F value	51.45*	27.72*	58.31*	51.40*	10.84*
	R^2	0.77	0.64	0.80	0.77	0.42
	Growth rate	7.15	7.55	7.24	5.69	6.59
		Study Period (Jan 2004-July 2020)				
Arrivals	F value	3.76	6.95*	4.38*	16.30*	8.62*
	R^2	0.20	0.31	0.23	0.52	0.36
	Growth rate	5.57	5.06	6.44	9.87	9.05

**Significant at 5% level of confidence*

4.3 Seasonality analysis of selected commodities

The seasonality in prices and arrivals is a cause of availability of produce and its demand in various seasons. Therefore, if the arrivals are more supplies are more and prices are less and vice versa. Thus, it is an inverse relationship between the demand and supply in which both the law of demand and law of supply are in operation. The results of the findings revealed that in all the commodities high seasonal indices are observed from March to June indicating high post-harvest arrivals during these months. During the peak season there is a high post-harvest arrivals so prices are low, but in off seasons the prices are high due to shortage and lack of storage facilities. There we can observe reverse relation between prices and arrivals. But in case of castor seed, as it is both Kharif and Rabi crop, the prices are high and arrivals are low in Kharif season and in Rabi season it is vice-versa.

In the months from July to September, the seasonal indices of prices for castor seed as shown in Table 3 was as high as 104.01, while as in case of arrivals, the seasonal index was as high as 207.13 in the month of April. The highest seasonality index in case arrivals was observed in the months of March and April in case of Coriander (245.43 and 208.98), Cumin (239.08 and 178.48) and Turmeric (226.03 and 218.02). In case of Soybean and Turmeric, the seasonal index for prices was high in the months from April to September, which reveals that there is lack of storage facilities and the production during these months was very low which needs to be redressed by improving the post-harvest techniques, so that the arrivals of these commodities get increased and availability should be throughout the year so that the prices get minimized.

Table 3: Seasonality indices of prices and arrivals of selected commodities from Jan 2004 to July 2020

Months	Castor	Coriander	Soybean	Cumin	Turmeric
January					
Prices	98.53	98.42	97.80	101.54	93.52
Arrivals	67.89	50.22	103.81	53.96	50.40
February					
Prices	98.90	89.66	99.06	97.26	95.57
Arrivals	96.37	107.07	68.05	107.35	140.86
March					
Prices	97.66	96.43	99.77	94.07	98.94
Arrivals	149.94	245.43	44.07	239.08	226.03
April					
Prices	98.16	101.42	105.50	94.72	102.22
Arrivals	207.13	208.98	39.66	178.48	218.02
May					
Prices	96.56	97.97	106.97	95.98	104.45
Arrivals	204.00	150.88	39.17	134.79	159.27
June					
Prices	97.35	98.67	104.47	96.87	104.42
Arrivals	103.97	92.33	48.93	101.10	97.71
July					
Prices	102.42	102.40	105.04	102.70	106.19
Arrivals	68.86	55.93	53.56	77.55	66.44
August					
Prices	104.01	103.74	102.08	104.43	106.76
Arrivals	51.27	41.17	36.36	54.20	51.69
September					
Prices	103.47	101.64	97.16	101.60	102.84
Arrivals	60.73	63.05	46.20	62.33	45.98
October					
Prices	99.64	102.98	90.50	102.48	95.44
Arrivals	66.43	56.73	278.83	53.75	36.28
November					
Prices	101.51	104.67	93.88	105.45	95.30
Arrivals	52.85	59.22	284.78	70.53	38.41
December					
Prices	102.45	102.94	96.59	103.95	94.02
Arrivals	58.18	55.82	175.52	54.85	52.75

4.4 Unit root test results

To examine the stationarity of the prices and arrivals, Augmented Dickey-Fuller unit root test has been utilized. To diagnose the stationarity characteristics, the test has been conducted using two models. First, a model with only intercept and second, a model with both intercept and trend. The test was employed at the level and first difference for all the selected commodities. Here, the logarithmic values of both prices and arrivals were considered for further analysis. At levels, ADF test indicates that the null hypothesis of non-stationarity cannot be rejected. *Panel A* of Table 4 reports the ADF test at level and *Panel B* at first difference. These findings reveal that all the prices and arrivals of the selected commodities become stationary after the first difference even at 1% significance level. Panel C reports the critical values at confidence level of 1, 5 and 10%. For example, castor seed t-test statistics for intercept model from Panel A is -1.61 at level of prices and lies within the acceptance zone of null hypothesis at 10% confidence interval, thus inferring that the series is non stationary. Whereas the t-statistics for the first difference of prices for castor seed from Panel B is -9.46, this lies outside the acceptance zone and hence inferring that the series is indeed stationary.

Table 4: Unit root test results

Panel A: ADF test at Levels

Commodities	Intercept only	Intercept & Trend
Castor Seed		
Prices	-1.61	-2.13
Arrivals	-5.35*	-5.56*
Coriander		
Prices	-1.68	-2.24
Arrivals	-6.76*	-7.22*
Cumin		
Prices	-2.03	-2.45
Arrivals	-5.31*	-6.14*
Soybean		
Prices	-1.61	-3.16
Arrivals	-6.40*	-7.14*
Turmeric		
Prices	-1.47	-1.82
Arrivals	-4.60*	-5.15*

Significance at 1% level of confidence

Panel B: ADF test at First differences

Commodities	Intercept only	Intercept & Trend
Castor Seed		
Prices	-9.46*	-9.48*
Arrivals	-10.26*	-10.29*
Coriander		
Prices	-9.93*	-9.91*
Arrivals	-9.93*	-9.910*
Cumin		
Prices	-8.92*	-8.74*
Arrivals	-9.03*	-8.99*
Soybean		
Prices	-10.21*	-10.18*
Arrivals	-12.78*	-12.75*
Turmeric		
Prices	-8.24*	-8.22*
Arrivals	-9.40 *	-9.39*

Significance at 1% level of confidence

Panel C: Critical values at 1, 5 and 10% level of confidence

1%	-3.46	-3.99
5%	-2.88	-3.43
10%	-2.57	-3.13

Similar analysis for remaining commodities infers both models with log prices were stationary at first difference and non-stationary at level, while as, in case of arrivals, they were stationary at both level and at first difference. After testing for unit root, long-run relationship between prices and arrivals was estimated using cointegration tests.

4.5 Cointegration test results

The cointegration tests were conducted on log Futures prices and Mandi spot prices of the five commodities using two methods: (1) Johansen trace test and (2) Johansen maximum eigen test. As these tests were sensitive to lag selection, VAR was used to determine the appropriate lag length as per the AIC criteria. Table 5 reports the Johansen cointegration test results, which imply a long-run relationship between the Futures prices and Mandi prices. *Panel A* reveals that all the price series were cointegrated at 1% significance level. Both the trace test and maximum eigen test indicate identical results and hence support the cointegration between the Futures prices and Mandi spot prices. For example, the trace statistic and maximum eigen test statistic for castor seed were 45.39 and 41.99 (*Panel A*, Table 5) with the null hypothesis of no cointegration (r = 0) and the critical values at 1% significance level were 24.60 and 20.20, respectively (*Panel B*, Table 5).

Table 5: Cointegration test results

Commodity	**Zero cointegrating vector (r = 0)**		**One cointegrating vector (r = 1)**
Panel A: Cointegration results			
	Trace	**Max. eigen**	**Trace and Max. eigen**
Castor seed	45.39*	41.99*	3.40
Coriander	44.39*	41.27*	3.12
Cumin	35.32*	31.09*	4.23
Soybean	48.71*	45.94*	2.78
Turmeric	29.89*	27.61*	2.28

Panel B: Critical values for trace statistics and max. eigen value test statistics

No. of cointegrating vectors	**Trace statistics**			**Max. eigen values**		
	10%	5%	1%	10%	5%	1%
r = 0	17.85	19.96	24.60	13.75	15.67	20.20
r = 1	7.52	9.24	12.97	7.52	9.24	12.97

Note: **Significance at 1% confidence level.*

Therefore, the null hypothesis of zero cointegration can be rejected. Similarly, for the null hypothesis of one cointegrating vector (r = 1), trace and eigen statistics in the last column of Table 5 reveal that the null hypothesis cannot be rejected, thus suggesting that the log of futures prices and mandi prices were cointegrated with one-to-one long-run relationship for all the five commodities suggesting market efficiency in Indian agricultural commodity markets.

4.6 Parametric test for estimation of price trend

An attempt has been made to capture and identify the impact of different variables on the prices of selected agricultural commodities. The ordinary least squares estimation procedure was used to obtain the determinants of prices of five agricultural commodities under study: Castor seed, Coriander, Soyabean, Cumin and turmeric. Only those variables were included in the model which gave the best fit. The log values of 7 variables were taken which includes Arrivals, Production, Area, Yield, Import, Export and Seasonality. The log values were taken to give the best results to the model. The dummy variables were included to capture the shifts in the intercept of the function. These variables include Infrastructure, Road, Electricity and Transport. The results of these estimates are presented in (Table 6). The estimates of the function revealed that out of 7 exogenous variable 5 variables appear to have a significant role in the price discovery process at 5 per cent level of significance. These variables include Arrivals, Production, Area, Export and Seasonality. All of the dummy variables included in the model have shown a significant impact of the prices of the selected agricultural commodities. The estimates of R^2 and F statistics indicated the model to be best fit wherein, specified exogenous variables explain above 90 per cent of the total variation in the prices of agricultural commodities except in case of Turmeric which showed above 50 per cent variation only. The overall yield of the commodities needs to be increased with proper institutional support so that the supply of these commodities can be made available throughout the year to have desired impact on the prices of the agricultural commodities.

Table 6: Price Supply functions of the different agricultural commodities (Price of the commodity as a dependent variable)

Variables	Castor Seed	Coriander	Soybean	Cumin	Turmeric
Constant	0.545 (0.64)	0.943 (0.07)	0.238 (1.33)	0.208 (-1.44)	0.107 (-1.89)
Log Ar_t	0.071 (1.90)	0.049* (2.13)	0.008* (3.03)	0.399 (0.86)	0.023* (2.52)
Log Pr_t	0.0003* (4.60)	0.055 (2.07)	0.001* (3.82)	3.03e-^{06}* (7.20)	0.018* (2.63)
Log Are_t	0.08 (1.87)	0.018* (2.64)	3.69 e-^{07}* (8.56)	1.94 e-^{06}* (7.48)	0.020* (2.57)
Log Yi_t	5.3e-^{08}* (9.95)	0.160 (1.45)	0.925 (-0.09)	0.001* (4.01)	0.062 (2.01)
Log Im_t	0.601 (0.53)	0.0007* (4.18)	8.32 e-^{06}* (6.60)	0.949 (0.06)	0.100 (1.75)
Log Ex_t	0.18 (-1.38)	0.055 (2.07)	0.0005* (4.34)	1.91e-^{08}* (10.75)	0.001* (3.87)
Log Se_t	8.22e-^{08}* (9.62)	2.235e-^{05}* (6.04)	5.71e-^{08}* (9.89)	0.001* (4.01)	0.062 (2.01)
DIN	1.09e-^{05}* (6.45)	0.0001* (5.20)	2.05e-^{05}* (0.09)	0.0001* (4.99)	0.035* (2.31)
DRD	5.03 e-^{06}* (6.90)	0.002* (3.53)	8.4e-^{05}* (5.33)	0.0002* (4.69)	0.0001* (4.96)
DEL	0.003* (3.61)	0.008* (3.04)	9.55 e-^{06}* (6.52)	0.003* (3.39)	0.035* (2.31)
DTR	0.002* (3.62)	0.004* (3.34)	9.94e-^{07}* (7.90)	6.74e-^{06}* (6.73)	0.0005* (4.37)
R-squared	0.98	0.99	0.97	0.97	0.88
Adj. R-squared	0.93	0.97	0.93	0.91	0.53
F-statistics	22.70	48.07	20.41	17.72	4.69
Significance F	0.001	0.0002	0.001	0.002	0.050

**Significance at 5% levels, t-statistics are in parentheses*

4.7 Non-parametric and Semi-parametric tests for estimation of price trend

Trend analysis of prices, export, import, area, production, yield and arrivals using nonparametric (Loess) and semi-parametric (spline) regression are presented in the tables 7, 8, 9, 10 and 11. In Table 7 the value of R^2 for prices of castor seed was 0.73 for Loess and 1.28 for Spline regression. Similarly for all the variables the R^2 values are highest in case of Spline regression, which implies that semi-parametric test was better fit than the non-parametric test. The AICc, RMSE, MAPE, MAE, MaxAPE and MaxAE values comes out be small for Spline regression for all the variables taken into consideration. The values of the variables were initially fitted at the smoothing parameters in order to obtain the best fit of the data points. The graph of the data points in the neighbourhood of the smoothing parameters were obtained and looked for the curve which covers all the points of the data. The one which covers maximum points is the best fit of the data points. In Figure 1 the smooth curve fits are obtained for prices of Castor seed in the neighbourhood of smoothing parameters i.e., at 0.3, 0.44, 1.00 and 1.50. It was observed that the best fit was obtained at smooth=0.44, similarly the smoothing parameters were obtained for other variables also. Likewise in Figure 4 smooth fits for production of Soybean were plotted in the neighbourhood of the smoothing parameter at 0.50, 1.00, 1.30 and 1.50 and it was observed that the best fit obtained for smooth=1.00. When we compare the R^2 values of parametric, non-parametric and semi-parametric tests, it was found that parametric models perform very well in visualizing the past trends where the non-parametric and semi-parametric models fails to.

Table 7: Non-parametric, Semi-parametric test results for Castor seed

		Prices	Export	Import	Area	Production	Yield	Arrivals
AICc	Loess	16.92	24.61	20.10	7.30	10.99	12.52	21.28
	Spline	4.44	14.41	13.94	14.07	13.85	13.71	10.63
RMSE	Loess	895.30	100644.14	11000.54	17.57	57.04	232.53	11896.07
	Spline	563.52	98500.84	10055.92	17.41	61.35	222.94	9236.99
MAPE	Loess	0.35	0.31	0.34	0.26	0.22	0.20	0.49
	Spline	0.22	0.31	0.23	0.26	0.24	0.19	0.40
MAE	Loess	25.60	284.94	113.98	3.58	6.54	13.35	98.74
	Spline	17.79	282.91	109.85	3.60	7.12	13.00	82.39
MaxAPE	Loess	37.78	29.88	20.77	25.13	15.25	11.80	72.64
	Spline	18.86	28.21	18.12	24.03	13.23	10.92	44.17
MaxAE	Loess	2010.69	233242.00	25291.00	49.76	102.38	504.61	23577.00
	Spline	1802.20	223113.31	23998.53	48.01	121.27	479.50	23617.66
R^2	Loess	0.73	0.89	0.83	0.45	0.78	0.39	0.66
	Spline	1.28	0.90	0.85	0.46	0.89	0.43	1.06

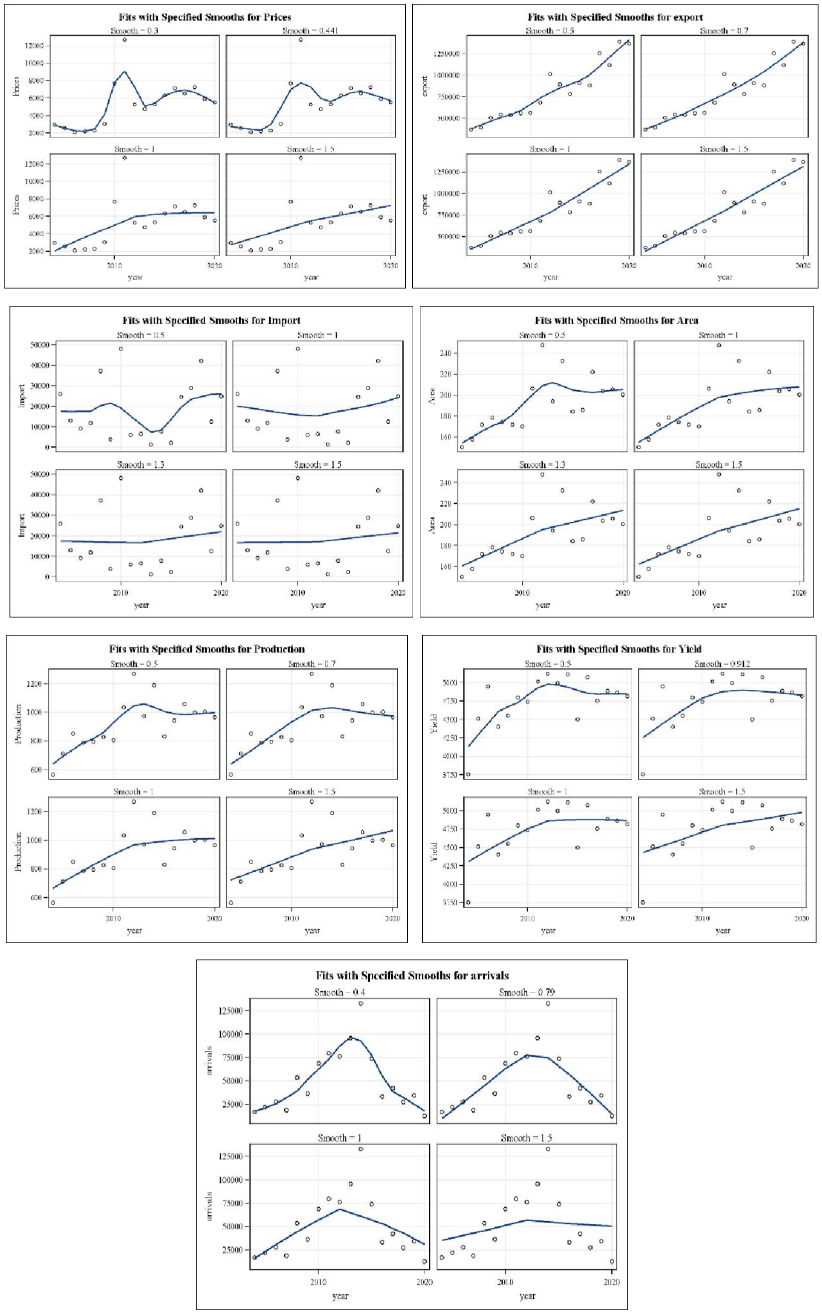

Fig. 1: Fits with specified smooths for Castor seed

Table 8: Non-parametric, Semi-parametric test results for Cumin

		Prices	Export	Import	Area	Production	Yield	Arrival
AICc	Loess	15.84	26.08	20.63	10.29	8.85	8.55	18.72
	Spline	7.41	5.80	14.94	12.61	11.34	10.34	15.00
RMSE	Loess	1257.44	209732.98	13754.54	72.56	29.91	50.84	5292.12
	Spline	477.28	67220.25	14055.92	65.87	26.22	3.54	5336.07
MAPE	Loess	0.29	1.28	0.81	0.31	0.29	0.28	0.74
	Spline	0.19	0.26	0.82	0.29	0.26	0.07	0.74
MAE	Loess	31.98	405.72	107.98	7.36	4.75	6.25	66.51
	Spline	19.83	206.56	109.85	6.98	4.39	1.56	66.60
MaxAPE	Loess	19.22	2418.98	204.77	37.47	27.63	24.21	136.81
	Spline	7.86	17.58	180.12	23.96	21.51	2.73	163.23
MaxAE	Loess	2383.00	390889.00	32391.00	160.58	61.71	114.00	8462.70
	Spline	1077.52	173804.69	30998.53	150.10	55.05	10.03	8839.18
R2	Loess	0.85	0.88	1.33	0.81	0.87	0.64	1.28
	Spline	0.95	0.96	1.35	0.86	0.94	0.98	1.29

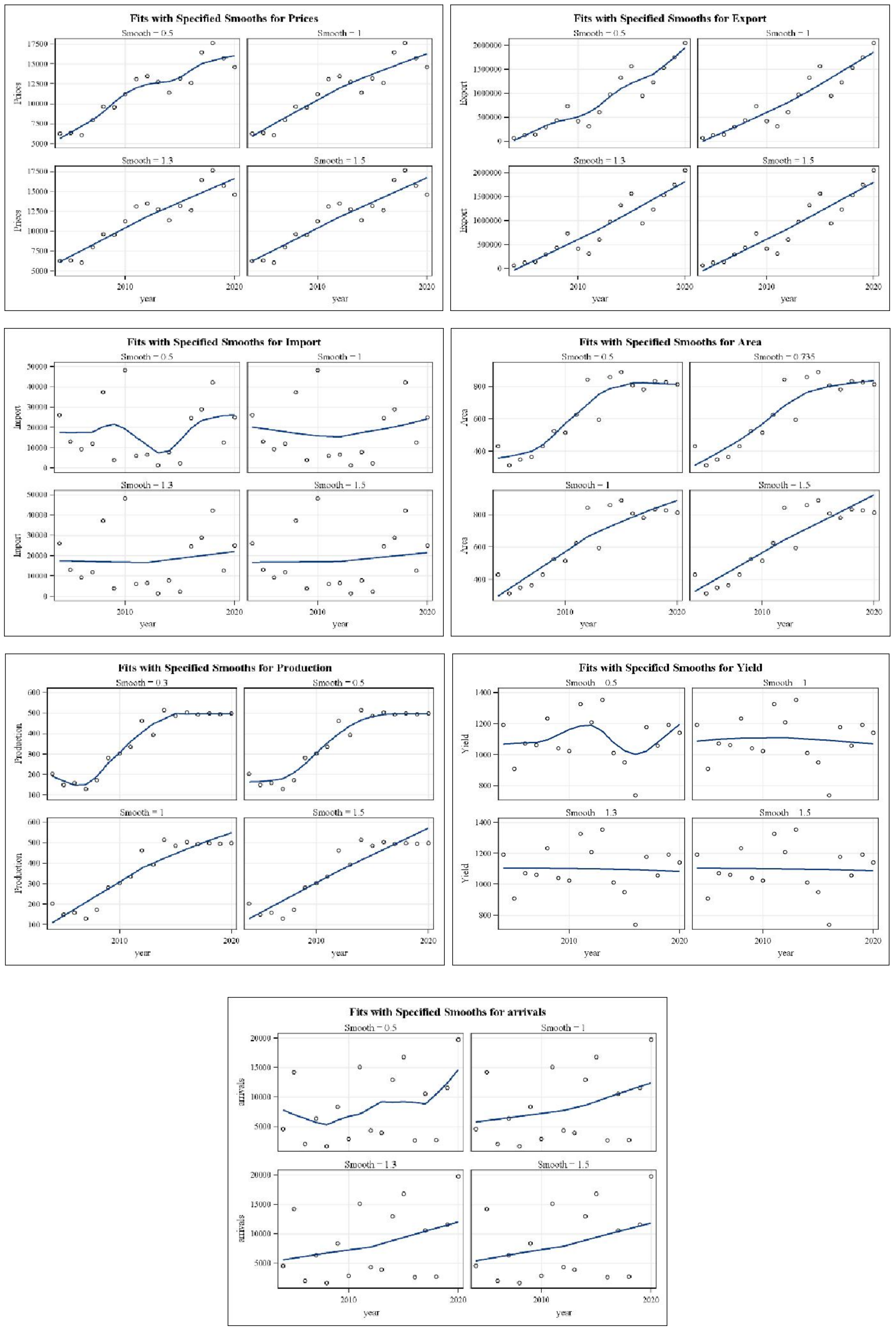

Fig. 2: Fits with specified smooths for Cumin

Table 9: Non-parametric, Semi-parametric test results for Coriander

		Prices	Export	Import	Area	Production	Yield	Arrivals
AICc	Loess	16.92	24.61	22.01	7.30	10.99	12.52	18.32
	Spline	4.44	14.41	12.60	14.07	13.85	13.71	14.86
RMSE	Loess	1452.46	100644.14	24451.26	17.57	111.22	232.53	1368.66
	Spline	531.56	98500.84	22172.46	17.41	107.48	222.94	1477.72
MAPE	Loess	0.38	0.31	0.50	0.26	0.29	0.20	0.38
	Spline	0.22	0.31	0.47	0.26	0.29	0.19	0.35
MAE	Loess	29.27	284.94	136.58	3.58	8.83	13.35	33.78
	Spline	17.50	282.91	127.26	3.60	8.91	13.00	35.24
MaxAPE	Loess	63.99	29.88	72.49	25.13	31.26	11.80	51.85
	Spline	18.86	28.21	67.39	24.03	28.11	10.92	24.07
MaxAE	Loess	4956.13	233242.00	57359.00	49.76	302.38	504.61	3150.23
	Spline	1628.80	223113.31	58326.01	48.01	278.57	479.50	14215.59
R2	Loess	0.48	0.89	0.88	0.45	0.46	0.39	1.03
	Spline	0.84	0.9	0.89	0.46	0.50	0.43	1.10

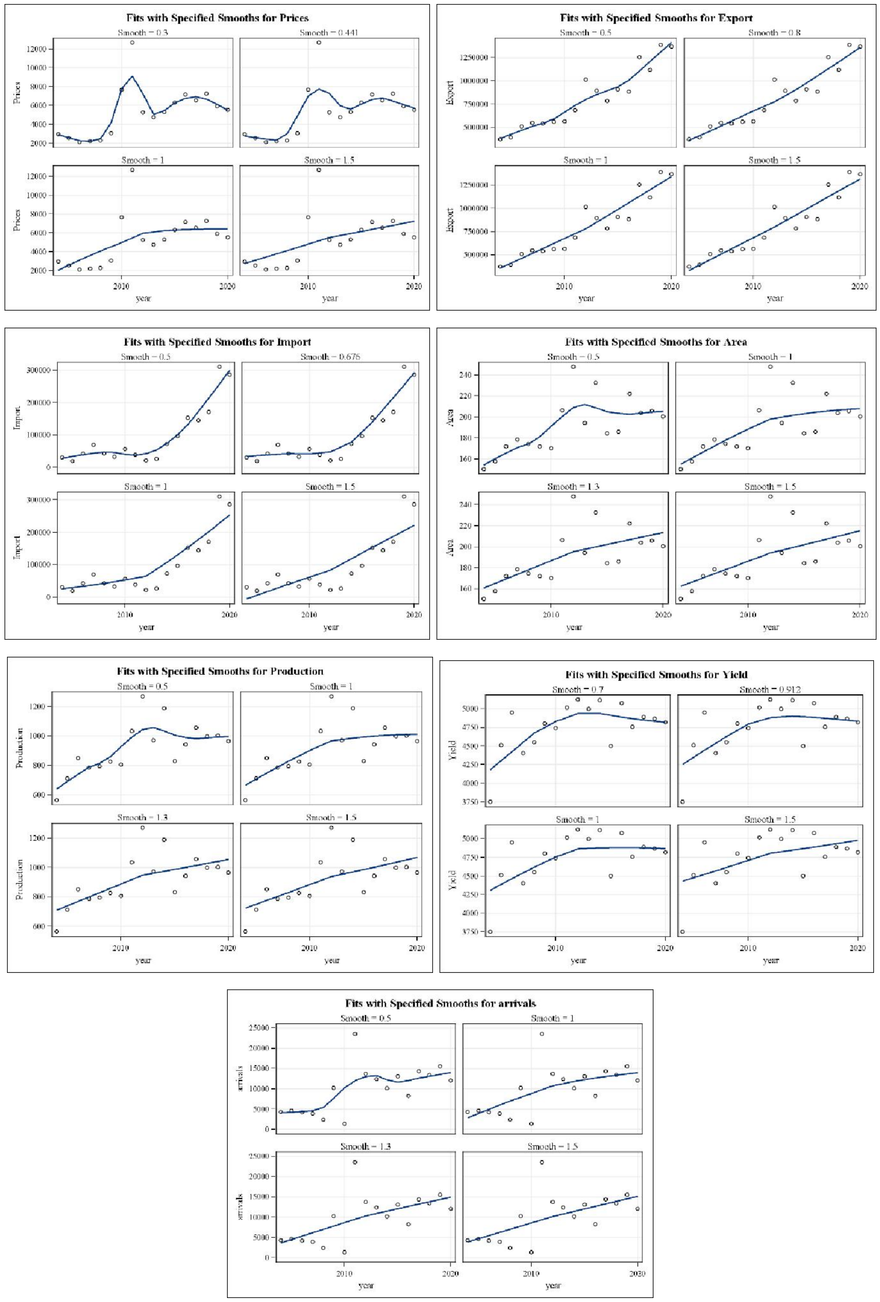

Fig. 3: Fits with specified smooths for Coriander

Table 10: Non-parametric, Semi-parametric test results for Soybean

		Prices	Export	Import	Area	Production	Yield	Arrivals
AICc	Loess	12.92	28.31	12.45	13.50	16.12	11.57	26.05
	Spline	7.69	7.69	13.12	12.76	12.11	15.00	10.38
RMSE	Loess	186.81	410240.49	257213.93	338.15	1443.27	148.62	167179.90
	Spline	114.68	0.46	4.96	328.09	1198.22	149.55	144884.96
MAPE	Loess	0.27	0.64	0.54	0.16	0.32	0.33	0.56
	Spline	0.19	0.00	0.10	0.16	0.29	0.33	0.52
MAE	Loess	12.83	567.77	371.74	16.33	33.26	11.08	374.53
	Spline	9.24	0.60	1.35	15.67	30.51	11.02	342.65
MaxAPE	Loess	15.08	97.83	90.36	7.48	28.37	32.45	69.83
	Spline	7.50	0.00	5.14	6.68	23.79	32.73	66.22
MaxAE	Loess	360.98	951833.00	591921.00	815.00	3255.20	354.69	350346.00
	Spline	243.61	0.98	19.92	733.59	2674.79	359.35	320568.15
R2	Loess	0.91	0.59	0.92	0.89	0.45	0.03	0.62
	Spline	0.95	1.00	1.00	0.93	0.59	0.04	0.74

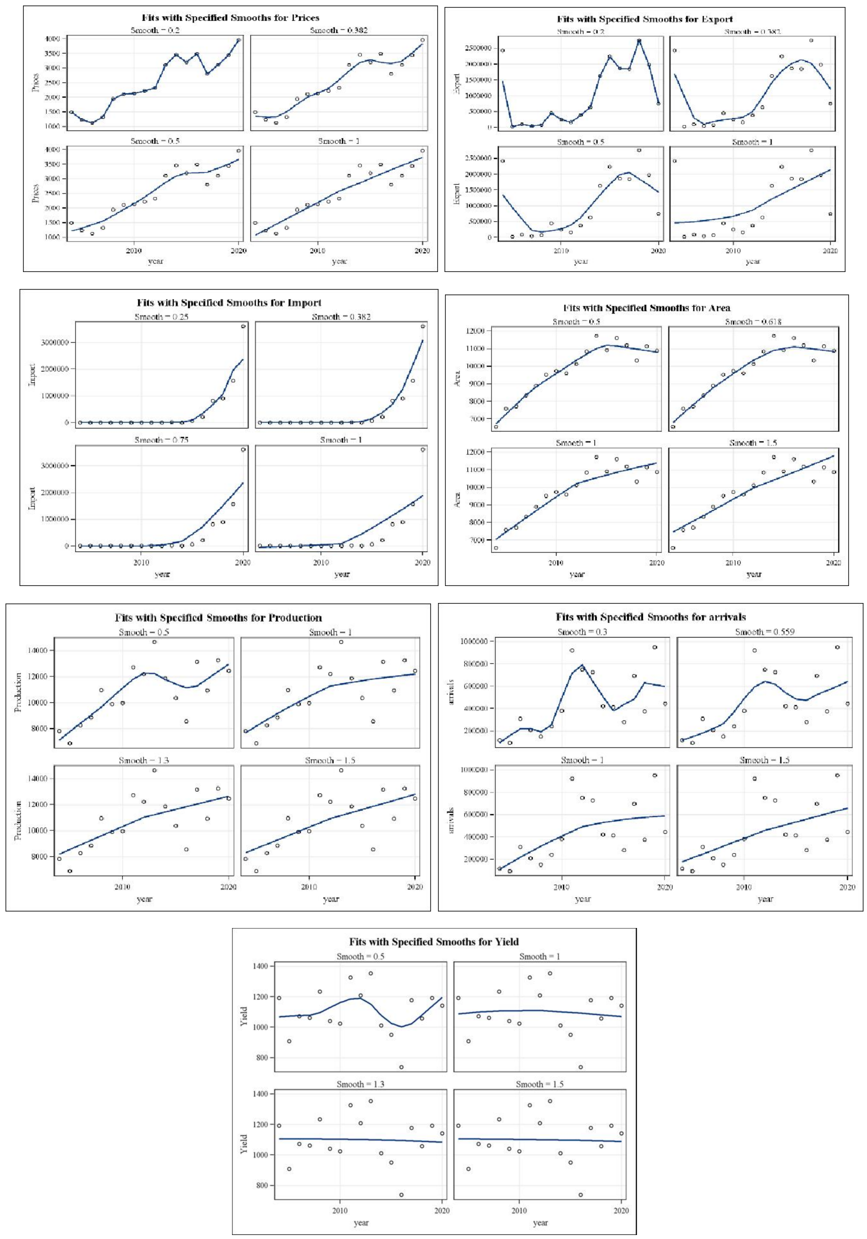

Fig. 4: Fits with specified smooths for Soybean

Table 11: Non-parametric, Semi-parametric test results for Turmeric

		Prices	Export	import	Area	Production	Yield	Arrivals
AICc	Loess	16.99	24.60	22.01	7.30	10.99	12.52	18.32
	Spline	10.23	14.50	12.60	14.07	13.85	13.71	14.86
RMSE	Loess	1452.46	100644.14	24451.26	17.57	111.22	232.53	4350.63
	Spline	531.56	44366.78	22172.46	17.41	107.48	222.94	4479.89
MAPE	Loess	0.38	0.31	0.50	0.26	0.29	0.20	0.58
	Spline	0.22	0.23	0.47	0.26	0.29	0.19	0.57
MAE	Loess	29.27	284.94	136.58	3.58	8.83	13.35	53.91
	Spline	17.50	200.83	127.26	3.60	8.91	13.00	54.54
MaxAPE	Loess	63.99	29.88	72.49	25.13	31.26	11.80	140.59
	Spline	18.86	12.95	67.39	24.03	28.11	10.92	152.10
MaxAE	Loess	4956.13	233242.00	57359.00	49.76	302.38	504.61	13768.46
	Spline	1628.80	75205.11	58326.01	48.01	278.57	479.50	14215.59
R2	Loess	0.48	0.89	0.88	0.45	0.46	0.39	0.86
	Spline	0.84	1.00	0.89	0.46	0.50	0.43	0.89

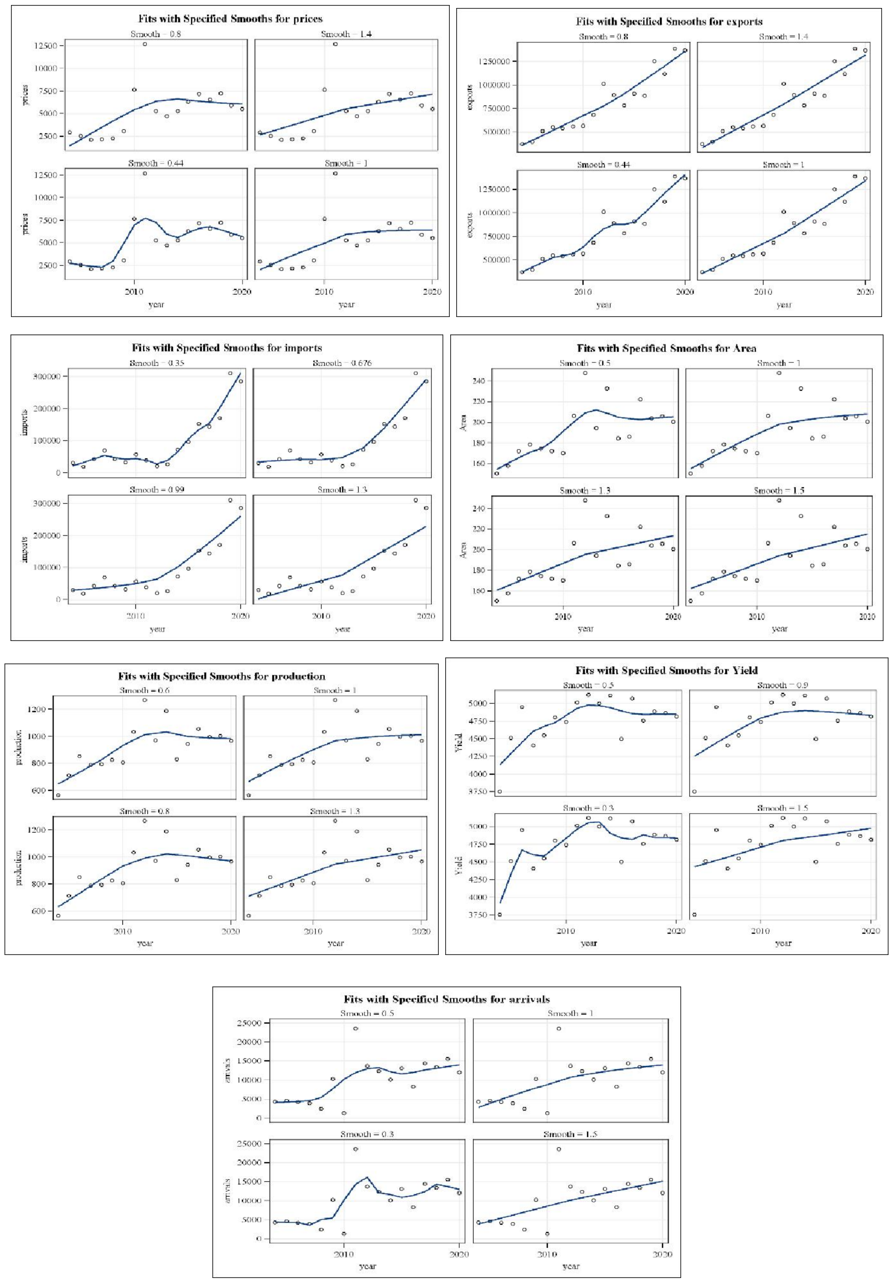

Fig. 5: Fits with specified smooths for Turmeric

Among the nonparametric and semiparametric regression, the spline regression has shown the lowest values of AICc, RMSE, MAPE, MAE, MaxAPE and MaxAE for prices, export, import, area, production, yield and arrivals in all the selected agricultural commodities in India hence spline regression was observed as the best fitted model among the two. Parametric regression usually utilized in studying the trend seems to perform better than the nonparametric and semi-parametric regression. And out of the nonparametric and semi-parametric regression methods the semi-parametric regression (spline) was the best fit for the trend analysis of the selected agricultural commodities in India.

4.8 Granger Causality test results

Granger causality test was performed to measure the short-run lead-lag relationship between the Futures and Mandi spot price returns after the series were checked for stationarity as mentioned earlier using unit root test. Here return stands for logarithmic values of prices. The test results in table 12 indicated bidirectional causality for Cumin and Soybean, Whereas, unidirectional causality for Castor seed, Coriander and Turmeric with Futures price returns causing Mandi spot price returns. Prices in both exchanges as well as Mandi's were capable of predicting the prices in bidirectional Granger causality results. However, exchange futures prices were dominant in most of the cases with high F-statistics. For example, in case of Cumin, the F- statistics was 118.53 for the null hypothesis of futures prices does not Granger-cause Mandi spot returns, whereas F-statistics was only 4.26 for the null hypothesis of Mandi spot returns does not Granger-cause futures returns. The results for unidirectional causality indicate that the information first gets reflected in the futures prices, which then gets transmitted to Mandi spot market prices. These indicate that the futures market were leading and hence price discovery function occurs in these markets.

Table 12: Granger causality test results for selected agricultural commodities

Commodity	Lags	Null Hypothesis	F-statistics	Prob.	Direction	Result
Cumin	2	Futures prices does not granger cause Mandi Prices	118.53	3.e^{-34*}	FP → MP MP → FP	bidirectional
		Mandi prices does not granger cause Futures Prices	4.26	0.01		
Castor seed	4	Futures prices does not granger cause Mandi Prices	13.85	2.e^{-06*}	FP → MP	unidirectional
		Mandi prices does not granger cause Futures Prices	0.51	0.60		
Soybean	2	Futures prices does not granger cause Mandi Prices	662.20	7.e^{-87*}	FP → MP MP → FP	bidirectional
		Mandi prices does not granger cause Futures Prices	5.57	0.004		
Coriander	2	Futures prices does not granger cause Mandi Prices	33.27	4. e^{13*}	FP → MP	unidirectional
		Mandi prices does not granger cause Futures Prices	0.05	0.94		
Turmeric	2	Futures prices does not granger cause Mandi Prices	53.83	3. e^{13*}	FP → MP	unidirectional
		Mandi prices does not granger cause Futures Prices	0.84	0.43		

Chapter-5

DISCUSSION

5.1 Examination of growth in the prices and arrivals of selected commodities

To study the behaviour of prices in response to arrivals of various commodities has remained an area of interest with the researchers over a period of time because the prices usually fluctuate with time owing to the movement in the marketing forces (demand and supply), especially with those agricultural commodities that have a lot of export potential. This uncertainty in the prices of agricultural commodities was influenced mostly by the annual variation in production, low price elasticity of demand and effect of the seasonal variation on agricultural production (Khalon and Tyagi, 1989). There has been a positive and significant growth rate in the prices of agricultural commodities with Cumin showing the highest growth rate of (9.87%) in arrivals followed by Turmeric (9.05%) and the lowest in Coriander (5.06%) as against the prices in crops where the growth was highest, *viz*., Coriander (7.55%) followed by Soybean (7.24%) and lowest (5.69%) in Cumin, respectively. Sahoo and Singh(2017) observed similar results for Bengal gram which they opined were either due to unavailability or lack of storage facilities and suggested that improvement in the storage facilities to improve the retention capacity of the farmers through remodeling of warehouse structures, storage chambers is urgently needed.

5.2 Seasonality analysis of selected commodities

The seasonality in prices and arrivals is a cause of availability of produce and its demand in various seasons. Therefore, if the arrivals are more, supplies will automatically be more and vice versa (Law of demand & supply). Thus, there exists an inverse relationship between the demand and supply. A linear equation and moving averages to examine the trend as well as seasonal variation of arrivals and price was adopted (Singh, 2000). The results revealed that in all the commodities high seasonal indices are observed from March to June indicating high post-harvest arrivals during this stretch of year/season. During the peak season, prices were low owing to high post-harvest arrivals, but in off-seasons the prices were high owing to lack of shortage of supplies and storage facilities. In this manner an inverse relation between prices and arrivals was observed, however, in Castor seed, grown both as Kharif and Rabi crop, the prices were high and arrivals were low in Kharif season and vice-versa in Rabi season. During July to September, the seasonal indices of prices for Castor seed were as high as 104.01, compared to arrivals where the seasonal index was as high as 207.13 in the month of April. The highest seasonality index in case of arrivals during the months of March and April respectively was observed as (245.43 and 208.98) in Coriander (239.08 and 178.48) in Cumin and (226.03 and 218.02) in Turmeric. The oscillatory movements affecting the prices are regular in period and amplitude. The long-term price behaviour is approximately linear and the cyclical trend is less pronounced (Mehta, 2000). In Soybean and Turmeric, the seasonal index for prices was high from April to September, indicating that there is lack of storage facilities and the production during these months is very low which needs to be redressed by improving the post-harvest techniques, so that the arrivals of these commodities are increased and availability made throughout the year to keep the prices under check.

5.3 Unit root test results

Once the seasonal component is removed, the unit root test is applied to test if the time-series data follows a covariance stationary process (Hill *et al.*, 2008). The Augmented Dickey-Fuller unit root was used to examine the stationarity of the prices and arrivals and further to diagnose the stationarity characteristics. The test was conducted using two models, *viz* (i) model with only intercept and (ii) model with both intercept and trend. This was done to check whether the prices and arrivals are cointegrated or not. The test was employed at the level and first difference for all the selected commodities. The logarithmic values of both prices and arrivals were considered for further analysis. At levels, ADF test indicated that the null hypothesis of non-stationarity cannot be rejected. These findings reveal that all the prices and arrivals of the selected commodities become stationary after the first difference even at 1% significance level. The results of the present study were in consonance with the study done by Manogna and Aswini (2000) on price discovery and volatility spillover of spot and futures agricultural commodity markets in India, in which they observed similar results for stationarity of the agricultural commodities. The t-test statistics for intercept model of Castor seed was found to be -1.61 at level of prices which lies within the acceptance zone of null hypothesis at 10% confidence interval, thus inferring that the series is non stationary. Whereas the t-statistics for the first difference of prices for Castor seed was -9.46, which lies outside the acceptance zone and hence inferring that the series is indeed stationary. Similar analysis for remaining commodities infers both models with log prices being stationary at first difference and non-stationary at level compared to arrivals, which were stationary at both level and at first difference. Similar results were obtained by Chand (2000) which concluded that all commodity price series become stationary after first difference and non-stationary at level.

5.4 Cointegration test results

The cointegration analysis reflects the long-run movement of price indices, although in the short run they may drift apart. The market efficiency evaluation under cointegration analysis recognizes that time series for spot and futures prices are usually non-stationary variables (Shen and Wang, 1990; Fortenbery and Zapata, 1993; Wang and Ke, 2005) and if these series are found to be non-stationary, then it is necessary to test for cointegration as a pre-condition for market efficiency and unbiasedness (Kellard *et al*., 1999). The cointegration test was conducted on logarithmic prices and arrivals of the five commodities using two methods: (1) Johansen trace test and (2) Johansen maximum eigen test. As these tests are sensitive to lag selection, VAR was used to determine the appropriate lag length as per the AIC criteria. The results of Johansen cointegration test revealed a long-run relationship between the prices and arrivals and concluded that all the price series are cointegrated at 1% level of significance. Both the trace test and maximum eigen test indicate identical results and hence support the cointegration between the prices and arrivals. These observations are in agreement with those of Mushtaq *et al.* (2008). The existence of cointegration between the spot and futures prices confirms the first necessary condition for long-term market relationship (Raghavendra *et al*., 2016). For example, the trace statistic and maximum eigen test statistic for castor seed are 45.39 and 41.99 with the null hypothesis of no cointegration (r = 0) and the critical values at 1% significance level are 24.60 and 20.20, respectively. Therefore, the null hypothesis of zero cointegration can be rejected. Similarly, for the null hypothesis of one cointegrating vector (r = 1), trace and eigen statistics reveal that the null hypothesis cannot be rejected, thus suggesting that the log of prices and arrivals are cointegrated with one-to-one long-run relationship for all the five commodities suggesting market efficiency in Indian agricultural commodity markets. The foregone discussion suggests that even though the price series are integrated, there could still be disequilibrium in the short run due to the price adjustments over the years which might not happen instantaneously or simultaneously (Wani *et al*., 2015).

5.5 Parametric test for estimation of price trend

An attempt has been made to capture and identify the impact of different variables on the prices of selected agricultural commodities. The ordinary least squares estimation procedure was used to obtain the determinants of prices of five agricultural commodities under study: Castor seed, Coriander, Soyabean, Cumin and turmeric. Only those variables were included in the model which gave the best fit. The log values of 7 variables were taken which includes Arrivals, Production, Area, Yield, Import, Export and Seasonality. The log values were taken to give the best results to the model. The dummy variables were included to capture the shifts in the intercept of the function. These variables include Infrastructure, Road, Electricity and Transport. The case study done by Gbetnkom and Khan (2020) used the similar technique to estimate the determinant of agricultural export in Cameroon. The estimates of the function revealed that out of 7 exogenous variable 5 variables appear to have a significant role in the price discovery process at 5 per cent level of significance. These variables include Arrivals, Production, Area, Export and Seasonality. All of the dummy variables included in the model have shown a significant impact of the prices of the selected agricultural commodities. The estimates of R^2 and F-statistics indicated the model to be best fit wherein, specified exogenous variables explain above 90 per cent of the total variation in the prices of agricultural commodities except in case of Turmeric which showed above 50 per cent variation only. The overall yield of the commodities needs to be increased with proper institutional support so that the supply of these commodities can be made available throughout the year to have desired impact on the prices of the agricultural commodities.

5.6 Non-parametric and Semi-parametric tests for estimation of price trend

In order to check whether the parametric regression model is best fit for price trend analysis or not, a comparison was made by employing non-parametric (loess) and semi-parametric (spline) regression model on prices, export, import, area, production, yield and arrivals. The results of the tests revealed that R^2 for prices of castor seed is 0.73 for Loess and 1.28 for Spline regression. Similarly for all the variables the R^2 values was found to be highest in case of Spline regression, which implies that semi-parametric test is better fit than the non-parametric test. The AIC, RMSE, MAPE, MAE, MaxAPE and MaxAE values came out be small for Spline regression for all the variables taken into consideration. Various scientist *viz*. Aydin (2007) and Pal (2011) observed similar results where the spline gave the better results than the Loess smoothing. The values of the variables were initially fitted at the smoothing parameters in order to obtain the best fit of the data points. The graph of the data points in the neighbourhood of the smoothing parameters were obtained and looked for the curve which covers all the points of the data. The one which covers maximum points is considered the best fit of the data points. The smooth curve fits were obtained for all the commodities under study. When we compared the R^2 values of parametric, non-parametric and semi-parametric tests, it was found that parametric models perform very well in visualizing the past trends whereas the non-parametric and semi-parametric models fails to do so. Among the nonparametric and semiparametric regression, the spline regression exhibited the lowest values of AIC, RMSE, MAPE, MAE, MaxAPE and MaxAE for prices, export, import, area, production, yield and arrivals in all the selected agricultural commodities in India, hence spline regression proved the best fitted model among the two (Ismail *et al*., 2018). Parametric regression usually utilized in studying the trend seems to perform better than the nonparametric and semi-parametric regression and out of the nonparametric and semi-parametric regression methods the semi-parametric regression (spline) is the best fit for the trend analysis of the selected agricultural commodities in India.

5.6 Granger Causality test results

Since cointegration tests indicate only the existence of long-run relationship among exchange futures and Mandi spot prices, Granger causality test was performed to measure the short-run lead-lag relationship between the Futures and Mandi spot price returns after the series are checked for stationarity using ADF unit root test. Here returns stood for logarithmic values of prices. Granger causality results indicated bidirectional causality for Cumin and Soybean, whereas unidirectional causality for Castor seed, Coriander and Turmeric where futures market prices lead to Mandi spot prices. This implies that futures market discovers prices for these commodities and spot market prices are influenced by the futures market prices (Jabir and Kriti, 2011). For example, in case of Cumin, the F-statistics 118.53 for the null hypothesis of futures prices does not Granger-cause

Mandi spot returns, whereas F-statistics is only 4.26 for the null hypothesis of Mandi spot returns does not Granger-cause futures returns. The results for unidirectional causality indicate that the information first gets reflected in the futures prices, which then gets transmitted to Mandi spot market prices. These indicate that the futures market is leading and hence price discovery function occurs in these markets. Empirical findings suggest that there is a long-term relationship between futures and spot prices for majority of agricultural commodities under the study. This implies that futures market prices have enough ability to predict subsequent Mandi spot prices, i.e., to discover prices in spot market for these commodities. In the public commodity market, any initiative on futures market will have its anticipated impact on spot market for commodities (Raju and Karande, 2003) with cointegration and uni-directional relationship, where futures prices lead Mandi spot prices. Absence of cointegration between futures and spot prices of Castor seed, Coriander and Turmeric with uni-directional causality test where futures prices lead to change in Mandi spot prices, raises concern for market to be efficient, as this trend may cause rise in Mandi spot prices of these commodities due to inefficient futures market.

Research Gaps Addressed

- Most of the studies conducting on the subject used data for a period of six years. Some of the important studies include Pavabutr & Chaihetphon (2010), Mukherjee (2011), Baldi et al. (2011), and Srinivasan (2011) etc. Compared to these, the present study covers period of 16 years which has helped to reduce variability of the data and errors.
- While as most of the studies conducted previous studies used only parametric tests, as against the present study which made use Parametric, Non-parametric and Semi-parametric tests to identify the best fitted model for examining the trends in prices of the selected agricultural commodities in India.

- There present study has explored relationship between the exchange Futures prices and Mandi spot prices in India in a fairly detailed manner, especially at the individual agricultural commodity market, whereas, most of the studies I have come across while screening the literature have dealt with futures price and mandi price from the exchanges only but not from the actual market.
- The anticipated outcome of the present study is expected to help the market participants to get benefitted by isolating the vulnerability accrued to the participants on account of long chain of intermediaries and at the same time help the policymakers to plan/workout on the futures prices in such a way so that the effectiveness of the Agricultural commodity market gets established in India.
- The findings of the study provide a new view on the relationship between futures prices and mandi spot prices using the latest data confirming that the futures market is dominant in the price discovery process.

Chapter-6

SUMMARY AND CONCLUSION

The present investigation entitled "Supply behaviour and pricing of selected agricultural commodities in India: Comparative investigation into exchange and market pricing system" was carried out to study the effect of seasonality on the prices and arrivals; to identify the effect of various determinants on the prices and to examine the causal relationship between exchange and market prices of selected agricultural commodities in India. The study has perused secondary data to accomplish its specified objectives. The results obtained from the investigation are summarized as follows:

6.1 Findings of the study

- A positive trend was observed in the prices of most of the selected agricultural commodities in the recent years, where futures market has played a leading role in price discovery function and information processing.
- The behaviour of prices in response to arrivals for selected commodities, computed by using Compound growth rate, exhibited a positive and a significant growth rate for both prices and arrivals.
- The effect of seasonality on the prices was observed during the peak season owing to high post-harvest arrivals. A reverse relationship between prices and arrivals of all the selected agricultural commodities was observed. It was suggested that improvisation in the storage and infrastructure facilities be done, to facilitate the disposal of the commodities to ensure their availability throughout the year.
- The ADF unit root test was used to test the stationarity of the prices and arrivals, the results revealed that all the selected commodities are stationary at first difference and non-stationary at level.

- The Johansen's co-integration test was employed on log prices and arrivals of the selected agricultural commodities to check the long-run relationship between prices and arrivals. It was found that both prices and arrivals are cointegrated at 1 per cent level of significance suggesting market efficiency in the Indian agricultural commodity markets.
- The determinants of the prices revealed that out of 7 exogenous variables, *viz*., Arrivals, Production, Area, Yield, Import, Export and Seasonality 5 variables, *viz*., Arrivals, Production, Area, Export and Seasonality appear to have a significant role in the price discovery process at 5 per cent level of significance.
- All the specified exogenous variables explained above 90 per cent of the total variation in the prices of agricultural commodities except in case of Turmeric which showed above 50 per cent variation only.
- The non-parametric and semi-parametric regression test revealed that semi-parametric (spline) performs as the best fit model to examine the trend in the prices of the selected agricultural commodities.
- The short-run lead-lag relationship between futures and Mandi spot prices was performed using Granger causality test. A bi-directional causality was found in Cumin and Soybean, whereas, unidirectional causality was found in Castor seed, Coriander and Turmeric.
- Futures prices were found dominant in all the commodities indicating information gets first reflected in futures prices which then gets transmitted to Mandi spot prices, suggesting that price discovery function occurs in futures market.

The objectives of the study have been achieved and with that aim some of the policy suggestions/recommendations have been put forth.

6.2 Policy suggestions/recommendations

In the time of globalization and progression, Indian agricultural sector is likewise responding accordingly to reap the benefits. After a delayed denial and rigid guidelines, futures trading in the country in almost all agricultural commodities has been permitted by the Government authority under close watch of the FMC, Ministry of Consumer Affairs and Food and Public Distribution according to rules and guidelines of the Forward Contracts (Regulation) Act 1952. Within a brief time-frame of around seven years, the future trading in agricultural commodities has become a significant stage for different stakeholders in the commodity markets. In agricultural commodity markets, the government has been assuming a significant part in settling the market to ensure safeguarding interest of producers as well as consumers through minimum support prices, market assurance scheme and public distribution system. Nonetheless, with the declining government intercessions in agricultural commodities market, part of futures market in price discovery and price management has become very significant.

- Improved/advanced storage facilities or upgrading existing storage facilities through improvement in warehouse structure and storage chambers are urgently required to facilitate improvement in the retention capacity of the farmers. It will further help to reduce the post-harvest losses.
- Government must ensure to make available the reliable and consistent data of prices and arrivals on daily basis in various markets and should publish daily/weekly/fortnightly/ or monthly bulletin in regional as well as local language to keep the farmers updated about market prices in various markets. This will help in linking the distant markets and shall increase market efficiency.
- Farming community which are mostly illiterate and are unaware about selling their produce in exchanges, for that there is a pent up need to

introduce FPOs so that the farmers could be linked to the exchanges through the Farmer Producer Organisations.

- The productivity of tradable commodities through exchanges need to be increased and regulation of quality standards maintained through proper institutional support to ensure supply of these commodities throughout the year. This could facilitate the positive impact of prices on the said tradable commodities.
- The knowledge about futures prices is an important tool in formulation of price policy and market investment strategies by the stakeholders. Policymakers and regulators should emphasize the efficiency of futures markets and improve market participation by implementing appropriate trading strategies to enable the farmers and traders to take advantage of the market information.

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CERTIFICATE

Certified that all the corrections/amendments as suggested by External Examiner Dr. Alka Singh during Viva-Voce examination held on 27-12-2021 have been incorporated in the manuscript entitled **"Supply Behaviour and Pricing of Selected Agricultural Commodities in India: Comparative Investigation into Exchange and Market Pricing System"** submitted by **Mr. Mohammad Mubashir Kachroo (Regd. No. 2018-802-D).**

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