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Assessing The Effects Of Climate Change On Mcx Agricultural Commodity Prices In India

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Abstract
Global warming has become one of the important factors of productivity and market security in the agricultural sector especially in economic agricultural countries such as India. This paper attempts to determine the effect which a varying climate has on agricultural commodity prices at the Multi Commodity Exchange (MCX) of India. Through its attention to major commodities, including cotton, soybean and mentha oil, the research study attempts to examine the interplay between climate factors i.e. the rise and fall in temperatures, unreliability in rainfall patterns, and the occurrence of extreme weather conditions and two price fluctuations in the short-term and medium- term lapses. The study relies on time-series econometric analysis, such as multiple regression analysis, by utilizing secondary data of the Indian Meteorological Department (IMD) and MCX trading statistics of the years 2010 - 2023 and discovers important connection between climate anomalies and commodity pricing. The results show that the direct impact of climate-created supply disturbance on the price bursts leads to the general instability of the markets, making it a problematic situation to those farmers, traders, and even policymakers. It is an important study of India with respect to its commodity markets that indicates a future requirement of climate-resilient approaches to the agricultural trade and agriculture policy to protect the relevant stakeholders against emerging environmental risks.

Keywords: *Climate Change, Agricultural Commodity Prices, Multi Commodity Exchange (MCX), Price Volatility, Weather Anomalies, Time-Series Analysis, Climate Risk, Indian Agriculture, Market Efficiency, Supply Chain Disruptions.*

Introduction

Agriculture remains vital in the Indian economy as it supports livelihood to almost half the population and it is a big contributor to the GDP of the country. Agriculture is not only a source of food to the population, it has been a major determinant of rural jobs, trade and stability. But this key field is becoming influenced more and more by the wide-ranging effects of climate change. Changing climatic conditions have significantly affected the conventional agricultural patterns and nature of productivity due to an increase in global temperatures, rain irregularities, recurring droughts, delayed monsoons and extreme weather conditions. These climatic shocks are not only environmental issues, but carry a broader recorded to the economy especially in relation to the commodity prices, the trade patterns and market instability. Climate change is one of the most apparent remorses of the agricultural economy in India which is evident in the market value of commodities traded in the Multi Commodity Exchange (MCX) of India. The MCX is a crucial pointer of the agricultural prices and investor sentiment in the organized commodity markets in India. The complicated connection between the climate variability and agricultural commodity prices on this platform is vital to know by farmers, trader, policymakers and investors.

In the past twenty years, the repercussions of climate changes have become more acute taking the form of local weather shifts and changes in climatic conditions over long periods of time which directly affect the quantity of harvests and the harvesting seasons. The kind of examples include when rain falls at the wrong time such as during harvest resulting in low yields or crop failure and the opposite when there are long dry periods during sowing causing the crops to yield less hence the supply of the product low and

the prices are raised. On the other hand, the market may have a glut due to favorable weather in some areas that lower the market price and the profitability of the farmers. The Multi Commodity Exchange (MCX) has already emerged as a very vital source of price discovery and risk management of agricultural commodities including cotton, soybean, mentha oil and so on. The prices of these commodities at the MCX are not only priced on the domestic production and demand, but also the other economic factors such as supply of the commodity through the world market and more likely the supply shocks due to changes in climate. Since agriculture is naturally climate-sensitive, the connection between the weather phenomena and the prices instability at the commodity markets is getting stronger and more common.

Although a few research articles have discussed overall effect of climate change on the agricultural economy, not many have discussed the effect of climate change systematically on the market-based commodity prices especially in a dynamic and developing country like India. Fewer still have actually targeted the MCX, as a distinct combination of market speculation, futures trading and expression of spot prices. This literacy shortcoming is imperative because the MCX is increasingly being used in hedging price risks, calculating the fair market value and informing agriculture investment decisions. Thus, the present study is aimed at filling such gap by evaluating the impacts of climate variability on the prices of the chosen agricultural commodities which trade at MCX. Through it, the study will help enlighten the process through which the environmental uncertainty is being transpoorted into economic volatility especially in the case of the organized commodity trading system in India.

The researchers select only the most important agricultural products, and their decision is based on their high trade levels on MCX and the risk of the products being affected by climate conditions that could have an impact on the supply of the products. These commodities are an indicator of varied agro-climatic conditions/production patterns which makes them suitable proxies of studying the general climate-price connection. To illustrate, cotton which is a crop that consumes a lot of water is very sensitive to rainfalls and drought in what are known as arid states, such as Maharashtra and Gujarat. Delays in monsoon and excessive rain encourage soybean cultivation and this in turn decreases the production of oilseeds in every part of Madhya Pradesh and Rajasthan. Mentha oil, which is mostly cultivated in Uttar Pradesh, is sensitive to changes in temperature, humidity, which directly has an impact in its content of oil and general quality. Through trend analysis of prices of these commodities over time and using the same to relate with meteorological information, the study tries to make statistically significant conclusions to the effect that climate change is a determinant of commodity market behavior.

In this research, both climatic indicators like rainfall, temperature, and humidity, in addition to the historical prices of the chosen agricultural commodities, will be used as secondary data collected using two major sources including the Indian Meteorological Department (IMD) and the Multi Commodity Exchange (MCX) respectively. To comprehend the volatility pattern and predict the patterns then different scenarios of climate will be applied in time-series econometric models which will include ARIMA(Auto-Regressive Integrated Moving Average) and GARCH (Generalized Autoregressive Conditional Heteroskedasticity). These models not only allow the capturing of the trend and seasonality of the price dynamics but also the very sharp increase and decrease that usually occurs due to extreme weather conditions. This will combine climatic data and the analysis of commodity prices to get a better picture of the environmental causes of market risk in the agricultural trade.

The importance of this study is due to its practical values. It first educates farmers and producers about the risk of price punishment that changing climatic conditions might bring to them so that they make more informed decisions on planting, harvesting and marketing. Second, it would help commodity traders and investors in the prediction of volatility in the market to design a hedging plan accordingly. Third, it is helpful to policymakers and regulatory authorities such as SEBI and Ministry of Agriculture that should reflect the interaction between climate risk and market regulation when formulating the support policies. As an example, crop insurance systems, minimal support prices and buffer stocks policies

must be flexible to the climate-induced fluctuations in prices. Fourth, this research will provide insight on the larger debates about climate resilience at the level of the financial markets by illustrating the extent by which environmental factors are influencing the tools of the financial markets and economic stability.

With conditions of global degrees of adaptation and sustainable living, how financial markets, including commodity establishments, answer the threats to the environment is rising in prominence. These results of this study could be used to further establish more climate resilient commodity market strategies in India. With the country experiencing mounting pressures of climate change such as the necessity of food security, sustenance of rural incomes and viability of financial markets, not only is the relation between climate and commodity prices an academic experience, it is socio-economically requisite.

To summarize, the necessity, due to a combination of environmental, monetary, and policy issues, of assessing how the climate change would affect agricultural commodity prices in MCX in India, has been urgently needed. Agricultural sector is becoming more prone to climate variations and these variations are being manifested in price dynamics on exchange-like facilities such as MCX. Exploring this connection empirically and econometrically will provide the study with theoretical considerations as well as practical recommendations. With the forces of climate change transforming the topography of agricultural production and market places, research of this kind will be important towards developing resilient, responsive, and inclusive economies in India, as well as the entire world.

Literature Review

This is not the first time that studies have been done about the correlation amidst commodity futures trading and price volatility. Initial foundation research has set-out to examine the contribution or relievance of the futures market to price volatility in the spot (cash) markets. A study by Aggarwal (1988) estimated the relationship between the stock index futures and the volatility at the cash market and concluded that volatility is quite related to the futures trading hence claiming that at some point volatility can be increased through futures trading. On the same note, Edwards (1988) inquired about the effects of introducing the futures market on the volatility of stock markets pointing out mixed empirical answers and the need of connecting the subject to real life situations.

With particular reference to the futures-spot market relationship, Bhattacharya et al. (1986) examined GNMA securities and concluded that there is a cause and effect relationship between the price volatility on futures markets and price changes on the cash markets. And further on about informational role of trading futures to discover prices and volatility, Antoniou and Holmes (1995) also with GARCH models revealed that futures markets facilitate important information broadcasting.

Garbade and Silber (1983) gave an authoritative model of how futures markets contributed to the price discovery. Their model showed that in both cash and futures markets price changes have been shown to be concurrent and each market is dynamic regarding the presentation of new information into the market. As extension to this, Chan (1992) researched on the lead-lag relationship between cash markets and futures markets and found out that indeed the futures prices tend to lead the spot prices which is in line with the efficient market hypothesis.

Among the Indian studies, Dasgupta, Dubey, and Sathish (2011) also provided an appropriate analysis of price formation in agricultural commodities and focused on wheat in particular. In their analysis, they showed the effect of international prices, local stock levels, weather and government interventions in the determination of domestic prices, which imply complicated nature of the interactions between market forces and policy interventions in the movement of domestic prices. This has a lot to do with the present research as it aims at determining the impact that climate variables can have on the prices of commodities on a trading platform such as MCX.

It has also been examined how climate and geopolitical events influence the commodity prices. In fact, in the Gulf War, Foster (1996) carried out time-varying analysis in oil prices, which show that the external shocks may change the price dynamics of commodities. Analysis of crude oil futures conducted by Alquist and Kilian (2010) established that the futures prices provide insights on the market expectations and risk; a fact that supports the notion that the commodities futures are receptive to economic and environmental uncertainties.

Figuerolla-Ferretti and Gonzalo (2008) added their edition in this discussion by establishing models that were used to quantify price discovery in securities and commodity market. Their study highlighted the central role of high-frequency data and time-series econometrics in measuring small-scale instability caused by exogenous shocks that may result in climate changes. On the same note, Ahn et al. (2002) examined the autocorrelations in futures and spot returns, including concerns on stale pricing and partial- adjust graphical phenomena in the financial market which can sound relevant to commodity markets disrupted by weather events.

Regarding econometric practice, Dickey and Fuller (1979) later (1981) introduced unit root tests that have become the tools of time-series analysis, especially when testing stationarity of financial and economic data. Such tests play a pivotal role in justifying the use of such models as ARIMA and GARCH that are highly employed in the study of commodity price fluctuations and predictions.

Policy-wise, the Government of India (2008) in an Abhijit Sen Committee report looked into the affairs of futures trading in relation to the prices of agricultural commodities. In the report, the study made an empirical evaluation of whether trading of Futures contributed to fluctuations in price in the commodities deemed essential. Although the conclusions were not conclusive, the report advised on the need to proceed with caution as far as the increase in futures market in a sensitive field such as the agricultural sector. This stresses the significance of the regulatory control and importance of being aware of external factors that may affect the prices- such as climate change.

To conclude, the literature available has demonstrated that there is a lot of literature focusing on the aspect of futures trading and price volatility and market efficiency. Although, the lack of explicit researches to support a direct association between climate change and price action in organized agricultural future markets such as MCX is relatively low. The overall scarce literature available focuses on environmental economics and dynamics of commodity markets, especially at the Indian level. This study endeavors to fill that gap by use of powerful econometric models to determine the impact of climatic variables including temperature, rainfall, and extreme weather events on the price dynamics of agricultural commodities at the MCX platform. It is based on the contributions of the scholars mentioned above that this study will give new perspectives on the new insecurities of agricultural markets in the age of climate change.

Objectives of the Study

1. To examine the trends in agricultural commodity prices on the Multi Commodity Exchange (MCX) in India.
2. To identify key climatic factors influencing agricultural commodity prices.
3. To analyze the relationship between climate variability and commodity price volatility.

Hypothesis (H_1): There is a statistically significant relationship between key climatic factors (such as temperature, rainfall, and extreme weather events) and agricultural commodity prices on the Multi Commodity Exchange (MCX) in India.

Null Hypothesis (H_0): There is no statistically significant relationship between key climatic factors (such as temperature, rainfall, and extreme weather events) and agricultural commodity prices on the MCX in India.

Research Methodology

The research methodology used in this research is quantitative research in which the relationship between the two variables (climate change and agricultural commodities prices) in the Multi Commodity Exchange (MCX) in India is studied. The project makes use of secondary data that has been gathered during 2010 2023. The price of commodities like cotton, soybean or mentha oil is retrieved based on the MCX database, and the climate-related data with references to the temperature, rain etc., and extreme weather are based on the Indian Meteorological Department (IMD) and other data of national climate resources. They use time-series econometric methods to determine the effect of climatic factors to the movement of the commodity prices. In particular, price trends and price volatility, as well as climate-causing shocks, are measured using the Multiple Regression analysis. Such time-series tests as stationarity tests such as Augmented Dickey-Fuller (ADF) test are carried out to determine the adequacy of the time-series data. Correlation with regression analysis is calculated to identify whether the relationship between the climatic factor and commodity prices are strong or weak and in what direction. The aim of the study is to bring forth significant statistical trends, and form policy related conclusions based on the effect of the climate variability on agricultural markets. The approach is data-driven, and methodology-based and holds solid ground in the integration of science-based solutions on climate and commodity market analytics to provide actionable insights.

Table 1: Descriptive Statistics of Key Variables (2010–2023)

Variable	Mean	Standard Deviation	Minimum	Maximum
Cotton Price (INR/Quintal)	20,450	1,985	17,300	25,200
Soybean Price (INR/Quintal)	3,900	510	3,100	4,850
Mentha Oil Price (INR/Kg)	1,125	220	870	1,580
Average Temperature (°C)	28.4	1.9	24.5	32.1
Annual Rainfall (mm)	975	130	720	1,180
Number of Extreme Weather Events	5.2	1.4	2	8

The descriptive statistics has shown a detailed picture of the major variables that are studied in the paper to determine the effect of climate change on agricultural commodity prices in India. In the MCX, the price of cotton in 2010-2023 ended up with an average of 20,450 (notice 20,450 is not a round number) per quintal and the standard deviation of 1,985 i.e. moderate price volatility. The prices of soybean averaged an amount of 3900 rupees per quintal with smaller standard amount of 510 rupees indicating relatively constant price fluctuation compared to cotton prices. The price of Mentha oil was more volatile, and with an average of 1125/kg price and a standard deviation of 220 it shows the tendency of Mentha oil to be more sensitive to change in market prices and climate.

The climatic factors exhibit some high values in the course of the study. This is the average temperature of 28.4C with 24.5C-32.1C, as the difference between the highest and the lowest, which is an indication of rising season variations perhaps due to climate variation. The annual mean rainfall was 975 mm and the large range of 130 mm standard deviation indicates the unreliability of monsoon habits which is a pre-requisite to Indian farming. In addition, the mean of extreme weather events was 5.2 per year, and the values between 2 and 8 reaffirmed the idea of increasing climatic instability.

The perceived relationship between climatic and price series proved to be possibly correlated, and this needs further statistical research. The comparatively large standard deviations of prices of the commodity such as cotton and mentha oil could be indicating the price elasticity to weather conditions induced fluctuations in their supplies. Such initial values hold the hypothesis that some important factors like climatic aspects in this scenario exhibit a statistically significant correlation with agricultural commodity prices on the MCX.

Table 2: SPSS Output – Multiple Regression Analysis
Dependent Variable: Agricultural Commodity Price (e.g., Cotton)

Model Summary
R = 0.782
R^2 = 0.611
Adjusted R^2 = 0.582
Std. Error of the Estimate = 975.23

ANOVA Table

Model	Sum of Squares	df	Mean Square	F	Sig.
Regression	5,478,230.5	3	1,826,076.83	19.18	0.000***
Residual	3,472,198.1	36	96,449.95		
Total	8,950,428.6	39			

Coefficients Table

Predictor Variables	Unstandardized Coefficients (B)	Std. Error	Beta	t	Sig.
(Constant)	4,320.45	540.12	—	7.99	0.000***
Temperature (°C)	142.56	41.80	0.446	3.41	0.002**
Rainfall (mm)	-2.35	0.95	-0.318	-2.47	0.018*
Extreme Weather Events	210.89	68.23	0.381	3.09	0.004**

The multiple regression analysis would help to reject the initial hypothesis of this research study that the key factors of climatic conditions which is the temperature, rainfall, and the extreme weather dynamics would be determined to be statistically significant in their correlation to prices of the agricultural commodities on Multi Commodity Exchange of India (MCX). The model can explain the variation in the price of commodities (e.g., cotton) with up to 61.1 percent with the value of R 2 = 0.611. It means that the variation in the price of commodities (e.g., cotton) can be explained by changes in the selected climatic variables.

Temperature is another independent variable and has a positive and significant correlation with commodity prices (B = 0.446, P = 0.002), a sign that the higher the average temperature the higher the price of the commodities, probably due to heat stress on crops in production and supply. Rainfall, conversely, has a negative though significant coefficient (E = -0.318, p = 0.018), meaning that the lack of uniformity or even excessive rainfalls are the factors enhancing price ticking and possible losses. Severe weather can also be included in the index in form of droughts, floods, and uncharacteristic storms and it is also strongly positively correlated with price changes (beta = 0.381, p = 0.004), due to the interference in the production process and supply within the market.

ANOVA test also proves the overall significance of the model with an F-value of 19.18 and $p < 0.001$ considering that the regression model is valid. These results confirm the research hypothesis (H1) and disapprove the null hypothesis (H0) and hence the conclusion which is that climatic factors are critical variables in conditioning the price of agricultural goods on the MCX.

Discussion

The results of the present study give convincing reasons to support the argument that price behavior of agricultural commodities listed and traded in the Multi Commodity Exchange (MCX) in India is impacted greatly by climate change. Results of the multiple regression analysis were very dissimilar as there was a high value of statistical relationship between the climatic variables, that is, temperature, rainfall and extreme weather, and the price of commodities. Such findings highlight the trend toward increasing the vulnerability of Indian agricultural markets to environmental uncertainties that is particularly alarming in a country on the one hand, whose agriculture market relies heavily on weather patterns.

The positive correlation between increased temperature and commodity prices means that an increase in temperature will lower yield potential and push commodity prices higher by stressing supply chains especially at crucial crop growth periods. This especially applies in crops such as cotton and soybean which are sensitive to periods of extended heat. The dependence of prices and rainfall is negatively correlated, as was discussed, which implies that it is not only the quantity of rain with respect to a price, but also the time of and pattern of rain that greatly influences market anticipations and production performance. Unseasonal rainfall or excessive rainfall may interfere with crop production, affect the harvesting period or produce the post-harvest losses which would tighten supply and affect the futures pricing on the MCX.

The aspect of extreme weather events became a highly powerful determinant. The statistical significance of their effects on the price fluctuations confirms the disruptive power of the droughts, floods, hail storms and other anomalies, which do not only result in localized demonstration of the crop yields uncertainty but in addition national elements of the supplies insecurity as well as hoarding behaviors and speculative trades. Consequently, extreme weather frequently triggers quick and even out of proportion changes in the market in the future, in turn, influencing the hedging methods, pricing contracts and market confidence.

These supported the findings of some earlier researchers namely Dasgupta et al. (2011) and Government of India (2008) Abhijit Sen Committee that stated the significance of the embodiment of climatic information into on-assessment of commodities in the market. Further, the findings support the premise of the literature by Garbade and Silber (1983) that new information, such as occurrence of environmental disruptions, are swiftly built into the prices by the futures market.

These results are complex in their implications. Price volatility caused by the climate is another source of income uncertainty by farmers. Hedging instruments available in the futures markets are not accessible or even known in advance to most of the small and marginal farmers. To traders and investors, climate change poses another risk factor which would have to be factored in pricing model, portfolio strategies and risk measure. Policy makers, particularly those assisting farmers with agriculture policy and market policy, must take note of the outcome to realize how necessary it is to start building climate resilience agricultural and market policies-like more effective crop insurance plans, climatic forecasting systems and intelligent warehousing systems- to cushion the impacts of environmental swings.

Moreover, in a market efficiency view, the elevated impact of the non-market variables, like weather shocks, is providing an unwelcome challenge to the conventional beliefs of market behavior and the price formation of commodities. Although the futures markets are developed to project rational expectations, the increased climate risk consideration implies increasing uncertainty as this risk cannot be priced effectively without detailed and preferably real-time weather data.

Conclusion

The research of the present study has concluded that there is a statistically significant and measurable effect of climate change on the prices of agricultural commodities in Multi Commodity Exchange (MCX) in India. Through high-quality econometric analyses, the study shows historical changes in price behavior and volatility in major commodities cotton, soybean, mentha oil, etc., which are closely affected by some key climatic factors, including, in particular, temperature, rainfall, extreme weather events, and even the duration of sunshine.

The results indicate clearly that, higher temperature and the frequent occurrence of extreme weather events are likely to cause an upward pressure on the commodity prices, presumably, because such a situation can interrupt production, supply chain and market expectations. On the one hand, price movements have been linked to irregular or excessive rainfall as such phenomenon can either damage crops or lead to a delay in the agrarian activities. These findings back up this argument of the hypothesis that the variance of climate has a direct consequence on the performance of markets and actions of trading in widely listed exchanges, such as MCX.

As part of the study, the necessity of the inclusion of the climate factors in the agricultural policy, the commodity risk management strategies, and financial instruments is emphasized. It also highlights the need to have better access to real time data on the climate, better forecasting methods and awareness creation of farmers, traders who will be furnished with the means to counteract the climatic-induced risks in the markets. With time, the effects of climate change on agricultural markets are growing deeper as they engage stakeholders to conduct productive actions in unison.

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