Reconnoitering Price Discovery and Market Efficiency Process Among Indian HRITHIK Stocks Using VAR Causality and VECM Tests

Nupur Gupta [1]
Yash Dalal [2]

Abstract

The purpose of this paper was to ascertain the impact of futures prices on market efficiency and price discovery in India in HRITHIK stocks from 2017 – 2020. The paper investigated the impact of futures prices on market efficiency and price discovery in India in HRITHIK stocks from 2017 – 2020. The current study comprised the daily near-month futures and daily spot closing prices of the HRITHIK stocks from January 1, 2017 – December 31, 2020, including the COVID-19 pandemic period. The paper used the vector autoregression (VAR) Engel Granger causality test to test the short-run equilibrium between spot and futures prices and the vector error correction model (VECM) to test for long-run equilibrium. A bi-directional relationship was found among six stocks out of the seven HRITHIK stocks. This confirmed the causal relationship that futures prices have on the spot prices. The VAR Engel Granger causality test indicated that the spot market narrowly led the futures despite a bi-directional flow of information. The results from the VECM model proved that the futures market acted as the dominant market in the long - run. Usually, researchers have leveraged sector-wise stocks to provide insights into the futures market's function in price discovery. For the first time, HRITHIK stocks were analyzed to examine the cause-and-effect relationship for individual stocks in India's futures and spot markets. The study considered the pre-COVID 19 and the post-COVID 19 periods and investigated the impact of the pandemic on these stocks. The research used daily closing prices of HRITHIK stocks; however, intraday data could be more conclusive and accurate in revealing the dominant market.

Keywords : **futures market, price discovery, market microstructure, vector autoregression Engel Granger causality, Vector error correction model**

JEL Classification Codes : C12, C58, C87, G13

Paper Submission Date : May 15, 2021 ; Paper sent back for Revision : January 5, 2022 ; Paper Acceptance Date : January 30, 2022 ; Paper Published Online : February 15, 2022

This study strives to understand the effect of the futures market on price discovery as well as market efficiency through a systematic investigation of heavyweight stocks from the Indian secondary market, namely HDFC Bank, RIL - Reliance Industries Limited, ICICI Bank, TCS - Tata Consultancy Services, HDFC Ltd., and Kotak Mahindra Bank. These stocks are collectively known as the HRITHIK stocks. The imperative applications of financial derivatives make a solid justification for studying the impact of derivative pricing in select large-cap stocks, which account for nearly 50% of the weightage of NIFTY. This paper further

[1] *Associate Professor (Accounting & Finance Area) (Corresponding Author),* Jaipuria Institute of Management, Indore, Dakachaya, Indore Dewas Highway, Near Shipra Naka, Indore - 453 771 Madhya Pradesh.
(Email : nupur.g.bhattacharya@gmail.com) ; ORCID iD : https://orcid.org/0000-0003-1111-3572
[2] *Associate,* Sanat M Dalal Securities Pvt. Ltd., 1211, BSE Building, Dalal Street, Mumbai - 400 001, Maharashtra. (Email : dalal.yash11@nmims.edu.in ; yashdalal09@gmail.com) ; ORCID iD : https://orcid.org/0000-0001-9371-4704

DOI : https://doi.org/10.17010/ijf/2022/v16i2/162434

investigates the futures and spot market association during the COVID-19 crisis and draws measurable comparisons.

The financial derivatives market plays a crucial part in the economic progress and growth of a country. Price discovery, market efficiency, volatility reduction, and risk aversion are crucial economic functions provided by the derivatives market for various market participants (Debasish, 2009; Raju & Karande, 2003). This has enhanced trading volumes, thereby infusing more liquidity in the sphere of the financial markets. The movement of the spot prices is primarily affected by the activities of the three market participants in the futures market – speculators, arbitrageurs, and hedgers. Thus, it is imperative to understand the influence of one market on the other and its impact on price discovery and causality. This branch of study is popularly known as the study of the market microstructure (Madhavan, 2000; Vega & Miller, 2009), which plays a considerable part in understanding the design of financial markets. Theoretically, the futures market aids in price discovery and manages risk. Therefore, the futures price acts as a reference price for the forward market.

This paper analyzes the association of the futures and spot market prices of heavyweight stocks. To our knowledge, no literature is available on assessing the volatility in the spot and futures market of HRITHIK stocks in India. HRITHIK stocks account for nearly 50% weightage of the NIFTY Index, and an examination of the impact of COVID-19 will provide significant investment and trading tips for different market participants.

HRITHIK is a popular acronym popularized in recent years in the Indian stock market. It represents seven large-cap stocks: HDFC Bank Ltd., Reliance Industries Ltd., ICICI Bank Ltd., TCS Ltd., HDFC Ltd., Infosys Ltd., and Kotak Mahindra Bank Ltd. Together, these stocks have the highest weightage in the NIFTY of approximately 45% (Fernandes, 2020). Their weightage in NIFTY- HDFC Bank weighed 10.98%, Reliance Industries weighed 9.76%, ICICI Bank weighed 6.95%, TCS weighed 4.35%, HDFC Ltd. weighed 8.31%, Infosys weighed 5.34%, and Kotak Mahindra Bank weighed 4.49% of the NIFTY as of December 31, 2019 (Fernandes, 2020).

The ongoing COVID-19 pandemic saw a blood bath in the Indian markets. Since the recovery phase of the markets started in May 2020, the impact of the pandemic on these HRITHIK stocks was nothing significant. Table 1 briefly depicts the yearly returns delivered by these stocks against the major indices - NIFTY and Sensex. The annual returns for most HRITHIK stocks have been better than the indices. This holds good even for the year 2020, when the COVID-19 pandemic impacted all financial markets across the world. Barring the returns of ICICI Bank Ltd. and HDFC Ltd., the other five stocks achieved better returns than the market indices.

Table 1. ***Yearly Returns of HRITHIK Stocks and Market Indices***

Date	HDFC Bank Ltd.	Reliance Industries Ltd.	Infosys Ltd.	TCS Ltd.	HDFC Ltd.	ICICI Bank Ltd.	Kotak Mahindra Bank Ltd.	Sensex	NIFTY
1/1/2017 – 31/12/2017	45%	54%	8%	15%	35%	34%	35%	25%	26%
1/1/2018 – 31/12/2018	13%	20%	36%	35%	15%	22%	22%	6%	3%
1/1/2019 – 31/12/2019	19%	31%	1%	17%	23%	30%	30%	14%	12%
1/1/2020 – 31/12/2020	12%	28%	56%	32%	0.06%	– 2%	18%	15%	14%

Literature Review

Market Microstructure

The study of market microstructure (MM) examines how specific trading mechanisms affect the price formation process (O'Hara, 1995). MM in the derivatives market has an imperative influence on the price discovery activity, primarily since the market contains numerous potential buyers and sellers who strongly believe that the futures and options (F&O) market conveys information to the spot market. They act as an indicator impact of new information on the underlying price, which market participants leverage by hedging the position in the derivatives market to reduce risk.

Researchers (Awrey, 2016; Chanzu & Gekara, 2014; Lien & Zhang, 2008) in the past explored the legitimacy of the impact of the derivatives market on the process of price discovery in the underlying market. Between the futures and spot market, there can be various ways in which information may flow from one market to another. Either there may be complete independence, or both the markets may be fully integrated. The third case, which is the most likely one, is a mixture of the two. Usually, a leading market (where the initial price discovery takes place) is present, and then there is a satellite market (a market that follows the dominant one). After the initial price discovery, the new information mirrored in the dominant market is in turn relayed into the satellite market. There could be a case where both the markets are mutually dependent, and the information flows both ways, but there is still usually a more dominant market in this case.

The symmetric information-based asset pricing models do not work because they assume that the underlying problems of liquidity and price discovery have been completely solved (O'Hara 2003). Market microstructure stands as one of the fastest-growing fields in financial research due to the increased use and development of electronic and algorithmic trading. Traditional analysis has overlooked the actual process of price formation. In 1968, Harold Demsetz explained the importance of demand and supply of new knowledge for price-setting. This eventually led to the formation of the market microstructure.

Price Discovery

Price discovery (PD) has been described by Schreiber and Schwartz (1986) as the process of finding an equilibrium price. It is a process where the market incorporates new information into the prices and navigates it toward an appropriate equilibrium price. Market efficiency plays a crucial role in the pace at which this new information gets reflected in the prices. The market in which the initial price formation occurs due to the newly available information is the more efficient. However, the markets being effectively integrated leads to the movement of news from one market to another, thereby leading to 'price discovery' (PD).

Researchers primarily wanted to analyze which market, between the futures and spot, first reflected new information in its price. Garbade and Silber studied this in 1983 by using simultaneous price dynamics to model future and spot prices. Their study found that more than 70% of the new information is mirrored in the futures market for agricultural products. Harris (1989) analyzed the spot and futures prices of the S&P 500 in 5-minute intervals in 1987. His study found that extremities of movement in the spot and futures data were due to erratic trading frequencies. Even after Harris had amended that, the findings revealed the futures market preceded the spot market.

In their study, Stoll and Whaley (1990) used 5-minute interval data from 1982 – 1987 and overcame the infrequent trading issue by applying ARMA (autoregressive moving average) filter on spot returns. However, the findings yielded similar results to confirm that the futures market preceded the spot market by 5–10 minutes. Quan (1992), using the Granger causality test, discovered the lead-lag relationships between the spot and futures price

of crude oil. Their results indicated that the spot market narrowly preceded the futures, thereby proving to be the dominant one. According to Antoniou and Holmes (1995), the stock and index futures being introduced led to only a short-term impact on stock market volatility and not a long-term impact on the FTSE 100 index.

Mayhew (2000) made a focused and detailed review on the importance of using the lead-lag association between the futures and spot market for each asset under study. He found an extremely accurate way to measure the relationship and analyze price discovery between both markets. Various other authors and researchers had then decided to deep-dive into this topic of interest, realizing that the cause of the lag could be due to asynchronous trading. Frino et al. (2000) documented the lead-lag relationship for index futures returns against index returns on the Sydney Futures Exchange (SFE) for over 15 months, between 1995 to 1996. Their study found that the futures market is more dominant during the announcement of macroeconomic news than the cash market at the same time. This behavior was quite evident as investors who had stock-specific information preferred to trade in underlying shares; whereas, investors who acquired related macroeconomic information tended to trade in Index futures.

Reddy and Sebastin (2008), on Nifty data, found that the movement of information from the futures market to the cash market compared from the cash market to the futures market was quite prominent. Debasish (2009) analyzed stock price data for the Indian index for an extended range of 7 years, and concluded the evidence of the futures market dominating the underlying cash market. However, he also claimed there was a trend of diminishing dominance. Research results from Kumar and Pandey (2011) and Lokare (2007) proved that the futures market was more dominant than the spot market. This shows how widely divided various researchers worldwide are in their views on the impact of derivatives on price discovery.

Schlusche (2009) applied the VEC (vector error correction) model to examine the futures market and spot market of the DAX (German blue-chip index). The study revealed two crucial findings: volatility and not liquidity are crucial for PD leadership. Secondly, the futures market adds considerably to the PD process compared to the spot market.

Diving into a more recent study by Chen and Chung (2011), it was found that the options market effectively leveraged S&P's depository receipts (DR). This led to a substantial improvement in the quality of its underlying depository receipts, mainly due to the increase of liquidity and facilitation of price discovery. Rajput et al. (2012), using the VECM model, indicated a lead-lag relationship in the CNX NIFTY and concluded that the spot market had a dominant role. Kapoor (2014), through her detailed study on the CNX NIFTY data, ranging for a long span of 15 years, found the spot market preceding the futures market and was more dominant in the long run.

Narsimhulu and Satyanarayan (2016) examined the efficiency of commodity futures in price discovery and risk management for three agricultural commodities, that is, chana, chilli, and turmeric using VESM and Granger causality test for the period from 2004 – 2013. The VECM results revealed a long-run causality running from futures prices to spot prices, which enabled the spot market to adjust its short-run deviations from the long-run equilibrium path. The Granger causality test results revealed only a unidirectional causality from futures returns to spot returns of commodities - chilli and turmeric. Danak and Patel (2020) examined the efficiency of financial futures in the Indian stock market by investigating the speed of adjustments in futures and spot indices on NSE NIFTY 50. Their study used Engle-Granger's error correction mechanism (ECM) to find the price discovery that took place in the futures market, and the spot market followed it mostly with a lag of 9 minutes. Their study offered an opportunity to arbitrageurs as the integration did not take place before 9 minutes.

Seth and Sidhu (2021) examined the price discovery and volatility spillover for the period covering January 2007 – December 2018 in the prices of spot and futures for crude oil and natural gas in India. Their study concluded that the market participants might depend on the futures market's price changes for their investment and trading decisions. This was so concluded because in the long-run equilibrium relationship between spot and futures prices, the futures (spot) market led the spot (futures) market in most sample periods.

Purpose of the Study

- To ascertain the impact of futures prices on market efficiency and price discovery in India in HRITHIK stocks from 2017 – 2020.
- To determine the cause-and-effect association between futures and spot prices in HRITHIK stocks from 2017 – 2020.

The coinage of acronyms of popular stocks started with FAANG stocks, continuing the trend in India, popularly HRITHIK stocks, SALMAN stocks, SANJU stocks, BHARATH stocks came into use in 2017; hence, the period of the study has been taken from 2017. The futures market's impact on price discovery and market efficiency is a topic whose legitimacy has been extensively studied and researched in the past. However, as per our knowledge and available secondary literature review, no research has been done on HRITHIK stocks. Moreover, after the pandemic of COVID -19 hitting all the world markets, a study to include the year 2020 seems extremely important to draw meaningful conclusions.

Data and Research Methodology

Data Sources

The research is conducted on the HRITHIK stocks in the Indian market. The HRITHIK companies are a perfect yardstick to draw an accurate conclusion as they represent a large chunk of the NIFTY Index in the Indian stock market. They are a popular way of naming heavyweight stocks, just like the acronym FAANGM (Facebook, Amazon, Apple, Netflix, Google, and Microsoft) to represent IT companies on the Nasdaq in the USA. These HRITHIK heavyweight stocks contribute to nearly 50% of the overall index weightage of the Sensex/Nifty index weightage; hence, these companies were selected for the study to provide a focussed view.

The data selected for the study includes the daily near-month closing prices of the futures and spot market of HRITHIK stocks from January 1, 2017 – December 31, 2020 (four years). The study selected the near-month contract for stock futures as they are the most heavily traded, highly liquid, and most active compared to far-month futures contracts.

This study includes the COVID-19 pandemic period to ascertain the reaction of the derivatives market on the facilitation of price discovery and maintenance of market efficiency during that period. All futures and spot prices have been taken from the National Stock Exchange (NSE) website.

Research Methodology

Cointegration analysis is employed to investigate the relationship between the spot and futures markets in terms of their prices. The aim is to measure the short-run cointegration and the long-run equilibrium to attain a more definitive view. The first step before commencing with the cointegration test is to appropriately ascertain the order of integration of all the price series individually in the study. For this, the Augmented Dickey-Fuller (ADF) test is deployed to check for stationarity in the level of the individual spot and futures price data.

The test is based on the augmented equation:

$$\Delta X_t = \mu + \delta_t + p X_{t-1} + \Sigma^{k}_{j=1} \Upsilon j \Delta X_{t-j} + \varepsilon_t \qquad (1)$$

The *t*-statistic is used to test the null hypothesis ($p = 0$). The lag length *(j)* selected for this test is as minimal as possible to reduce the residuals of white noise.

After establishing the stationarity condition of the time series data, we further proceed to test whether there occurs a long-run equilibrium between the two price variables, that is, the futures data and spot data for the stocks that have been selected. This is required for checking long-term cointegration between the markets to prove market efficiency. This test is imperative to understand whether the price variables involved are effectively cointegrated in the long - run or drift apart without bound. Therefore, to ascertain the presence of cointegration, we investigate whether the final settlement futures prices and spot prices are effectively and significantly cointegrated using Johansen and Juselius cointegration test. This test has proven to be the most effective in assessing the long-run relationship between futures and spot prices, using the maximum likelihood technique or the trace test. These two tests enable the user to determine the presence of cointegration and the number of cointegrating vectors.

VAR (vector autoregression) model:

$$\Delta S_t = \alpha_1 + \Sigma^n{}_{i=1}\, \alpha_{11}(i)\Delta S_{t-i} + \Sigma^n{}_{i=1}\, \alpha_{21}(i)\, \Delta F_{t-i} + \varepsilon_{St} \qquad (2)$$

$$\Delta F_t = \alpha_2 + \Sigma^n{}_{i=1}\, \alpha_{21}(i)\Delta S_{t-i} + \Sigma^n{}_{i=1}\, \alpha_{22}(i)\, \Delta F_{t-i} + \varepsilon_{Ft} \qquad (3)$$

The ordinary least square (OLS) method of regression can be used to determine the vector autoregression (VAR) equations above. If the two markets are found to be cointegrated, it means that the two series have a uni-directional or bi-directional causal relationship. Based on the alpha figures, we can determine which market is dominant and which is the satellite. For example, if α12 above is non-zero and α21 is zero, the futures market, it can be deduced, is the more dominant market. In the same way, the spot market would be deemed more dominant if vice versa occurred. At the same time, a non-zero output for all the sets of variables would imply a bi-directional relationship between the price series.

Therefore, we use the VAR Granger causality test to evaluate the causal effect of trader's activities on the two series of prices, helping us ascertain the short-term relationship between the two markets for that stock. Granger causality states that: *Xt* causes *Yt* if we can better predict *Yt* by using all the available information than if the information apart from *Xt* has been used (Granger, 1969).

This causality test determines the results by examining whether past values can be used to explain the current values of the other variable, however, conditional on the second variable's past values. If this is the case, then the first variable is said to 'Granger-cause' the second variable.

The above tests, if deployed effectively, enable us to make inferences about the path of information movement between futures and spot markets of the selected seven companies for the study, thereby concluding whether there exists a uni-directional relationship where only one market influences the other or a bi-directional relationship is prevalent between both the markets, thereby, facilitating price discovery.

We define the spot return of security as:

$$RS_t = \text{In}\, S_t - \text{In}\, S_{t-1} \qquad (4)$$

where,

St = price at time *t* (day).

The futures return is defined as:

$$RF = \text{In}\, F_t - \text{In}\, F_{t-1} \qquad (5)$$

where,

Ft = Futures price of the nearby contract at time t.

We used the first difference of the daily futures returns *(Ft)* and daily spot returns *(St)* for our Granger causality test due to stationarity prevalent only at the first-difference levels. The Granger causality test estimates the regression models below to analyze the relationship between *'RSt'* and *'p'* lagged values of *'RFt'* and *'RSt'*:

$$RS_t = \alpha_0 + \Sigma^p{}_{k=1}\, \alpha_{1k} RS_{t-k} + \Sigma^p{}_{k=1}\, \alpha_{2k} RF_{t-k} + e_t \quad (6)$$

$$RF_t = \alpha_0 + \Sigma^p{}_{k=1}\, \alpha_{1k} RF_{t-k} + \Sigma^p{}_{k=1}\, \alpha_{2k} RS_{t-k} + e_t \quad (7)$$

The Granger test with VAR is deployed by using the *t*-test and interpreting the probability value to determine the causality and the flow of information in the markets. The lag structure suggested by the Akaike information criterion (AIC) was used for every stock. The $\log_{10}$ value of both the price series is used to arrive at a more accurate causality test result.

However, the Engel-Granger causality test only indicates the short-term relationship prevalent between the futures and spot markets as well as the causality direction in the short run. Therefore, we further apply the vector error correction model (VECM) to ascertain the long-run equilibrium for both the markets and the lead-lag relation that exists for the price variables.

The confirmation of the presence of cointegration using the Johansen and Juselius cointegration test would allow for a price discovery analysis using bivariate VECM estimation. The VECM model will effectively display the time-invariant estimates for the error coefficients or error correction terms (ECT) of each stock selected. Unlike the Granger causality model, which only indicates the short-term relationship of the spot and futures market, the VECM model will display the long-run relationship after all possible short-run adjustments.

Therefore, after using Johansen's cointegration test to search for cointegration in the spot and futures markets, after confirming the direction of short-term causality between the markets using the Granger causality test, we can move ahead with the VECM model to investigate the lead-lag relationship.

Bivariate VECM Model

$$\Delta s_t = \mu_{s,0} + \alpha_s ec_{t-1} + \Sigma^p{}_{i=1}\, \delta_{ss,i} \Delta s_{t-i} + \Sigma^q{}_{j=1}\, \delta_{sf,j} \Delta f_{t-j} + \varepsilon_{s,t} \quad (8)$$

$$\Delta f_t = \mu_{f,0} + \alpha_f ec_{t-1} + \Sigma^p{}_{i=1}\, \delta_{fs,i} \Delta s_{t-i} + \Sigma^q{}_{j=1}\, \delta_{ff,j} \Delta f_{t-j} + \varepsilon_{f,t} \quad (9)$$

where:

- $\mu_{s,0}$ and $\mu_{f,0}$ are intercepts.
- $\varepsilon_{s,t}$ and $\varepsilon_{f,t}$ are error terms that are assumed to be uncorrelated serially.

The above equations have an error correction that is deemed significant statistically. It indicates that the market is responsive to any price disparity or disequilibrium between spot and futures. In simpler words, it can also be said that one market responds to a change in the other. Assuming the estimations yield a statistically significant error correction coefficient for the spot market (α_s) but not for the futures market (α_f), in that case, the findings support the futures market playing a dominant role in price discovery and vice versa.

Empirical Analysis and Results

After completing the test for stationarity (Table 2), which is the primary pre-condition to progress further with the research, we employed the Johansen and Juselius cointegration test to check for cointegration between both the

Table 2. ***Augmented Dicky Fuller and Phillips – Perron Test at Level & First Difference***

		ADF (With Constant and Trend)	
Variable	**Market**	**Level**	**First Difference**
HDFC Bank	Futures	–2.030	–22.833
	Spot	–2.047	–22.912
Reliance Industries Limited (RIL)	Futures	–2.279	–30.250
	Spot	–2.299	–30.263
ICICI Bank	Futures	–2.672	–30.763
	Spot	–2.724	–30.846
Tata Consultancy Services (TCS)	Futures	–2.563	–29.846
	Spot	–2.496	–17.264
HDFC Ltd.	Futures	–2.944	–18.237
	Spot	–2.950	–18.705
Infosys	Futures	–1.441	–26.867
	Spot	–1.440	–29.423
Kotak Mahindra Bank	Futures	–2.750	–29.514
	Spot	–2.836	–29.890

Note. The significance level is 1%.

Table 3. ***Johansen & Juselius Cointegration Test***

		Trace Statistics Test		
HDFC Bank	$H_0 \rightarrow r = 0$	121.50	117.26	Cointegrated
	$H_0 \rightarrow r \leq 1$	4.24	4.24	
Reliance Industries Limited (RIL)	$H_0 \rightarrow r = 0$	115.32	110.33	Cointegrated
	$H_0 \rightarrow r \leq 1$	4.99	4.99	
ICICI Bank	$H_0 \rightarrow r = 0$	141.37	134.92	Cointegrated
	$H_0 \rightarrow r \leq 1$	6.45	6.45	
Tata Consultancy Services (TCS)	$H_0 \rightarrow r = 0$	503.28	496.82	Cointegrated
	$H_0 \rightarrow r \leq 1$	6.46	6.46	
HDFC Ltd.	$H_0 \rightarrow r = 0$	107.02	97.50	Cointegrated
	$H_0 \rightarrow r \leq 1$	9.52	9.52	
Infosys	$H_0 \rightarrow r = 0$	85.44	83.33	Cointegrated
	$H_0 \rightarrow r \leq 1$	2.11	2.11	
Kotak Mahindra Bank	$H_0 \rightarrow r = 0$	156.09	148.35	Cointegrated
	$H_0 \rightarrow r \leq 1$	7.74	7.74	

price series. Table 3 presents the results obtained from applying the Johansen trace test. For cointegration to exist between both the series, the null hypothesis critical value (@5%) of '$r = 0$' should be greater than the test statistic value (18.96), and the critical value (@5%) of '$r \leq 1$' should be lesser than the test statistic value (12.25). As can be seen from the results, cointegration exists on a large scale for all the stocks selected. This existence of cointegration confirms the long-term market efficiency, from which we can deduce that the futures market possesses enough ability to discover the subsequent underlying spot prices.

Then, we move on to the results of the vector autoregression Engel Granger causality test. This test is imperative to assess the short-run relationship and the relationship between the price series. To determine whether the futures market or spot market Granger causes another, the probability value should be less than the probability value of '0.05'. The lesser the *p*-value, the greater is the impact of that market on the subsequent market. This helps us conclude as to which market between the two is the more dominant one. The results in Table 4 depict a bi-directional relationship existing for six of the stocks in the study: HDFC Bank, Reliance, ICICI, TCS, HDFC Ltd, and Kotak Mahindra Bank, except for Infosys, where a uni-directional relationship is found in which the futures market is more dominant than the spot.

Further, for TCS and HDFC Ltd., it is apparent that even though a bi-directional relationship is prevalent, the futures market narrowly leads the spot market. However, for the remaining four stocks in the study (HDFC Bank, Reliance, ICICI Bank, and Kotak Mahindra Bank), the spot market narrowly leads the futures despite a

Table 4. ***Vector Autoregression (VAR) Engel Granger Causality Test***

Equities	Hypothesis	*t*-ratio	Probability	Direction	Interpretation
HDFC Bank	*F* does not cause *S*	2.217	0.0269	Bi-directional	$S \leftrightarrow F$
	S does not cause *F*	2.453	0.0144		
Reliance Industries Limited	*F* does not cause *S*	2.196	0.0284	Bi-directional	$S \leftrightarrow F$
	S does not cause *F*	2.218	0.0268		
ICICI Bank	*F* does not cause *S*	2.571	0.0103	Bi-directional	$S \leftrightarrow F$
	S does not cause *F*	2.682	0.0075		
Tata Consultancy Services	*F* does not cause *S*	2.512	0.0122	Bi-directional	$F \leftrightarrow S$
	S does not cause *F*	2.209	0.0274		
HDFC Ltd.	*F* does not cause *S*	3.118	0.0019	Bi-directional	$F \leftrightarrow S$
	S does not cause *F*	3.020	0.0026		
Infosys	*F* does not cause *S*	2.496	0.0127	Uni-directional	$F \leftrightarrow S$
	S does not cause *F*	0.615	0.5386		
Kotak Mahindra Bank	*F* does not cause *S*	2.856	0.0044	Bi-directional	$S \leftrightarrow F$
	S does not cause *F*	3.185	0.0015		

Table 5. ***Categorization of Causation Based on VAR Granger Causality Test***

Non-Directional	Uni-directional ($F \rightarrow S$)	Uni-directional ($S \rightarrow F$)	Bi-directional ($F \leftrightarrow S$)	Bi-directional ($S \leftrightarrow F$)
–	Infosys	–	Tata Consultancy Services	HDFC Bank
			HDFC Ltd.	RIL
				ICICI
				Kotak Mahindra Bank

Table 6. ***Results of Vector Error Correction Model***

	Adjustment Coefficients		Cointegrating Vectors		
	α (Futures)	α (Spot)	β (Future) lag1	β (Spot) lag 1	Constant
HDFC Bank	–0.061	0.1702	1	–1.0031	0.0095
Reliance Industries Limited	–0.0325	0.2945	1	–1.0006	0.0011
ICICI Bank	0.1509	0.5045	1	–1.0008	0.0013
Tata Consultancy Services	0.277	1.13	1	–1.0012	0.0027
HDFC Ltd.	–0.1822	0.0674	1	–1.0002	5.67E-05
Infosys	–0.1346	0.097	1	–0.9976	0.0074
Kotak Mahindra Bank	–1.84E-01	1.42E-01	1	–0.9987	–0.0044

bi-directional flow of information. The results strongly imply that both spot and futures markets impact each other's price formations and movements. Table 5 summarizes the results of Table 4.

Finally, we reach the VECM model to interpret the lead-lag relationship and long-run equilibrium in the selected markets. The estimates for both the error-correction coefficients are displayed in Table 6 for each of the HRITHIK stocks. It is observed from the results that the adjustment coefficients for the futures market (α_f) are negative and significant; whereas, the adjustment coefficients for the spot market (α_s) are positive, except for ICICI Bank and TCS, where α_f has a positive value and is not significant. This indicates disequilibrium in the spot and futures market in the long run for ICICI Bank and TCS prices. However, for the remaining five HRITHIK stocks, there is a long-run equilibrium that is indicated since the α_f is negative, and the α_s is expectedly positive, which would imply that when futures prices are beyond their equilibrium value, the spot prices for these five stocks adjust upward to correct the prior existent disequilibrium and vice versa. Hence, it can be interpreted that the spot market has a dominant role in the price discovery process in the long run since it is adjusting its prices towards the equilibrium level.

The seven HRITHIK companies play a significant role and significantly impact price discovery and market efficiency. The spot market displaying a dominant position in these companies gives us a fair understanding of its role in price discovery. However, the futures market has a significant role in creating this equilibrium in the short and long - run. The synergized relation between the spot and futures market enables the price discovery process and leads to long-run market efficiency. This present study provides a holistic picture of the impact of the derivatives market in India.

Conclusion and Implications

Leveraging the comprehensive daily data set from the NSE official website, we have effectively carried out a systematic analysis of the price discovery process in the spot and futures market for the selected HRITHIK stocks. The HRITHIK stocks being a significant driver of India's market index give us a more relevant picture of derivatives' impact on price discovery. Over the last year, the total market capitalization of these selected HRITHIK stocks increased by approximately USD 1.7 trillion (“BSE ranks among 10 most valued,” 2020). Of this, nearly 9 trillion (41%) came only from these seven HRITHIK stocks in the index.

A significant portion of the wealth in the Indian stock markets was created only from these seven stocks over the last year. After initially outlining the present status of the derivatives market in India up to the year 2020, a comprehensive and detailed study on the correlation of spot and futures data of seven equity stocks was executed to be cognizant of the fundamental dynamics of cointegration as well as price causality which help determine the

efficiency of the markets for the period faced by various market and economic conditions from January 1, 2017 – December 31, 2020. The study deliberately included the COVID-19 pandemic period to ascertain the reaction of the derivatives market in its price discovery role as well as maintenance of market efficiency during that period which was marked with high amounts of volatility where the 'India VIX' (volatility index) breached its historical high of 85.13.

After conducting the Johansen cointegration test on the log values of both price series of the HRITHIK stocks, it is proven that the markets are significantly cointegrated. This proves that the market was efficient and that the derivatives market provided an efficient hedge against price risk for the individual stocks. This cointegration indicates the developed and efficient nature of the market.

The VAR Engel Granger causality test results indicate the dominant direction in which the information flowed from one market to the other for the selected seven stocks in the short run. The results indicate that the futures market and spot market share a synergized relation with a bi-directional flow of information where the spot market has a crucial role in discovering and determining price.

These results from the present study are in line with the findings obtained by Quan (1992), Rajput et al. (2012), and Kapoor (2014), indicating that the spot market leads the futures market in the short and immediate term as well as in the long term. However, crucially, the results from the Granger causality test results as well as the VECM test prove that the futures market does have a pivotal role to play in price discovery as well, it clearly being the more dominant market in an extremely high market capitalized and reflective economy stock like HDFC Ltd. and TCS in the short - run. However, even in the long - run, all the futures markets for the HRITHIK stocks do have an imperative role in price discovery and market efficiency, and this role has only grown further in the maintenance of market equilibrium since its introduction in the Indian markets.

Further in-depth analysis of trading volume data and its relationship with efficient price discovery would help us understand whether thinly traded futures would change the results of price discovery. Another factor that future researchers could work upon is considering daily closing prices since intraday data could be more conclusive and accurate in revealing the dominant market. This paper will enable investors to enhance their decision-making process and predict better stock movement, especially in uncertain and unprecedented times like a pandemic. It will also help market regulators frame appropriate policies to curb excess volatility.

Limitations of the Study and Scope for Further Research

The research uses daily closing prices of HRITHIK stocks; however, intraday data could be more conclusive and accurate in revealing the dominant market. The analysis of causality and error correction is confined only to secondary data. The paper has used the VAR Engle-Granger causality model and vector error correction model. Hence, all the limitations of these econometric models apply to this study. The study period covers only four years. The paper has not analyzed the period from the second wave of COVID-19 onwards and its impact on the association of spot and futures market prices of the stocks under study. Future researchers can consider this area for future research.

Authors' Contribution

Mr. Yash Dalal conceived the idea and, with the help of Dr. Nupur Gupta, developed the qualitative and quantitative design to undertake the empirical study. Dr. Nupur Gupta designed the model and the computational framework while extracting research papers with high repute based on filtered keywords relevant to the study design. Dr. Nupur Gupta conducted an exhaustive literature review and found the research gaps. Mr. Yash Dalal

carried out the implementation and performed the calculations using Gretl, R-Studio, and E-views that Dr. Nupur Gupta investigated. Both the authors discussed the results and contributed to the final manuscript. Dr. Nupur Gupta supervised the entire study.

Conflict of Interest

The authors certify that they have no affiliations with or involvement in any organization or entity with any financial interest or non-financial interest in the subject matter or materials discussed in this manuscript.

Funding Acknowledgement

The authors received no financial support for the research, authorship, and/or for the publication of this article.

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About the Authors

Dr. Nupur Gupta is currently working as an Associate Professor (Finance & Accounting area) at Jaipuria Institute of Management, Indore. She has previously taught management students at the Frankfurt School of Finance and Management, Germany (Visiting Professor), NMIMS University, & K J Somaiya Institute of Management Studies and Research as Core Faculty.

Yash Dalal is working as an Associate with Sanat M Dalal Securities Pvt. Ltd. He did his MBA from the School of Business Management, NMIMS University, in 2021. He was a student of Dr. Nupur Gupta at NMIMS University.