Impact of Increased Derivatives-Trading in India on the Price-Discovery Process

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Executive Summary

Based on a study of the futures and options on NSE Nifty and ten other randomly-selected NSE stocks, we found that spot-market has been dominating the futures and option markets and that the dominance of futures market over options has diminished after the increase in STT (Security Transaction Tax). We propose that the STT on protective-put and hedged-call positions should be reduced, as clearly explained later in the paper, to give a boost to the option market. To our knowledge, this is the first paper to analyze price-discovery (PD) in India's single-stock-options market using the information conveyed by the option-prices and compare it to PD in the corresponding futures and spot markets. This is also the first paper in the Indian context to analyze the PD simultaneously in the three markets for the individual stocks (ten of which were selected by this study): option, futures, and spot. This is also the first paper to analyze PD in the market for futures and options on these ten stocks and on Nifty during three different regimes pertaining to STT (Security Transaction Tax). Though there are numerous studies on PD in the market for futures on Nifty and on single-stocks, there is only one study that has analyzed PD in Nifty-option market resulting from prices or returns and there are a couple of studies that have tried to ferret out the price-influencing information provided by Nifty-option open-interest and traded-value.

1. Introduction

This paper analyzes whether introduction of financial derivatives led to better price-discovery (PD) in India. First, we study whether, from the days of the introduction of futures and options on Nifty and ten selected individual stocks, the volatility of the price or return of the underlying asset increased or decreased. Then, we analyze whether price-formation in the derivative market leads, lags, is contemporaneous with, or is independent of price-formation in the spot market. We also look at the liquidity in the derivative market (as measured by the trade-value) and try to correlate it to the PD process. The paper is organized as follows. Section-2 provides a conceptual foundation of PD, Section-3 gives some relevant institutional information and data in the Indian context, Section-4 reviews the existing literature, and Section-5 concludes, with some suggestions for extension, after giving the details of the data, methodology, and results of this study.

2. Conceptual and Theoretical Foundation

2a. Market Microstructure (MM)

MM (market microstructure) studies "how specific trading mechanisms affect the price formation process" (O'Hara 1995). Price is determined by demand and supply. But how the buyer (or the demand) and seller (or supply) meet – or what the 'exchange' or the 'market' looks like - can vary drastically: from one-to-one face-to-face meeting on one extreme to program-trading on the other. But, the traditional equilibrium analysis has ignored the actual process by which prices are formed. Therefore, 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). It is Demsetz (1968) that brought in the relevance of the time dimension of demand and supply in price-setting, which, in some sense, led the foundation of market microstructure. He highlighted that even though demand and supply may match during a period (say an hour or a day), they may not match 'at every point'. So a buyer and seller may be willing to offer a premium for 'immediacy' which simple demand-supply analysis has ignored. Thus, the excess of ask price over bid price (the ‘bid-ask spread’) can be thought of as a mark-up paid for the “predictable immediacy of exchange” in organized markets (ibid).

2b. Market-Efficiency and Price-Discovery (PD)

Informationally efficient markets are those where price of each asset reflects, as soon as possible if not immediately, all ‘available’ new information about it; here, depending on the degree of efficiency, ‘available’ could mean historical, public, or all (including private), as we move up the ladder of efficiency. Thus, when new material information about an asset arrives in the market, it gets incorporated in the asset’s price very ‘fast’, how fast depending on the degree of the market’s efficiency. When multiple markets are there for the same asset, there can be differences in the degree of efficiency in reflecting the new information. So, one of the markets may be the most efficient in incorporating the new information; this market is where the ‘price formation’ – or the *initial* ‘price formation’ - takes place. Another market may be the least efficient. But, there is more. If the markets are all independent, ‘price formation’ processes in them are all independent. If they are integrated, however, then information flows from one market to another. In one extreme, price may form in one market and other markets just follow suit (‘borrow the prices’); here, the former is the ‘dominant’ market and the latter ‘satellites’ (Garbade and Silber 1979). But, it is also possible that price in each market reflects the new information only partially, and each market looks at the other market to gather more information. Then, price formation would be taking place in the different markets simultaneously, followed by each market taking information from the other markets and then revising its prices. The process of formation of prices is what we call ‘price discovery’ (PD). In initial studies on this issue, the futures market and the cash or spot market were taken as the two markets where PD could take place; researchers analyzed whether new information was reflected - through a change in the price - first in the futures market or first in the cash market (Garbade and Silber 1983). It is, of course, quite possible that price-changes in one market do not *always* lead price-changes in the other market, but does so only *more often* than the other way round (ibid). Anyway, the role of futures market in PD has been recognized for quite long (Working 1962); in fact, it is argued that the "function of primary price formation lies with the futures market" (ibid). Consistent with this, Garbade and Silber (1983) find, using US data for food and non-food commodities, that 75% of new information gets incorporated first in the futures prices and only then flows to cash prices.

2c. Basic Characteristics of Derivatives and Relationship of Their Value to Spot-Price

We just talked about 'futures'. What is it? It is a kind of contract. It binds two parties, buyer and seller, to transact a given quantity of a specified asset (of a particular quality in some cases) at a future date at an agreed-upon price called the futures price. Of course, due to a feature called marking-to-market (whereby the account books of both parties are adjusted everyday to reflect the change in the closing or 'settlement' futures price vis-à-vis the previous day), the agreed-upon price is paid over the life of the contract not in one-shot on the maturity-date, as is the case with a forward contract or, for that matter, other contracts like 'option'. An option differs from futures in the sense that, whereas futures binds both sides, an option gives one side – it can be the potential buyer or seller – the right and the other side the obligation. The option buyer has the right to buy (call) or sell (put) at a pre-specified price - called the strike-price or the exercise-price - whereas the corresponding option-seller has the obligation to sell (deliver) or buy (accept delivery) at that price; for this obligation, the seller charges a price, called premium, to the option buyer at the time of entering into a contract. Like futures, option also has a maturity-date, generally called the expiry-date and, depending on the option-type, it can be exercised on or before the expiry-date (American) or only on the expiry-date (European). But, as we can see, unlike in the case of futures, the transaction may not take place in the case of an option, if the option-buyer chooses not to (exercise his right). It may be worth pointing out that options on individual stocks in NSE of India used to be only of the American type earlier, but became only of the European type since November 2010. Both futures price and option price are functions of the prevailing spot (or cash market) price. Futures price is typically given by a simple function as follows: $f = S (1 + r – q + i)^T$, where f is the futures-price of the contract maturing at the end of T years, S is the current spot price, r is the risk-free interest rate (typically the compounded rate of return per year), q is the compounded annual return on the underlying asset, i is the compounded annual inventory cost like that for storage and insurance, and T is the years-to-maturity, the number of days between now and t expressed in years (and, thus, equal to days-to-maturity divided by 360 or 365). For stock options and stock-index options, q is typically the dividend-yield. If we use the APR (annual percentage rate) analogue instead of the compounded annual rate, the above equation would change to the following: $f = S (1 + APR – q + i) T$. The continuous-time version of the above equations is given as follows: $f = S e^{(r – q + i) T}$, where r, q, and i represent the continuously compounded rates of the variables as described above. So, in the simplest model, we can derive the futures-implied-spot-price as follows:

$$S = f / (1 + r) \qquad \dots (1)$$

where r is the interest rate between the trade-date and the futures's maturity-date.

As all the above equations show, f would always move up and down with the spot price. It is not that straightforward with option price or option premium: the call option price goes up when spot price rises, but the put option premium falls. There are many models that capture that, the most famous among them being the Black-Scholes model, which gives the call price and the put price, respectively, as follows. $\mathbf{C = S\, e^{-qT}\, N(d_1) - X\, e^{-rT}\, N(d_2);\ P = X\, e^{-rT}\, N(-d_2) - S\, e^{-qT}\, N(-d_1)}$,

where $\mathbf{d_1 = \dfrac{\ln\left(\frac{S}{X}\right) + \left(r - q + \frac{\sigma^2}{2}\right)T}{\sigma\sqrt{T}};\ d_2 = d_1 - \sigma\sqrt{T}.}$

Here, C is the call price, P the put price, X the strike-price or exercise-price of the option, and N(.) the cumulative probability distribution function for the standardized normal distribution. In this framework, it can be shown that the following parity relationship exists at any point between the prices of the call and put on the same asset with the same strike price and same expiration date: $C - P + PV(X) = S$, where PV(X) represents the PV of X, the strike-price and is given by $X/\{(1 + r)^T\}$ [which can also be represented as $X/\{(1 + APR*T)\}$], or its continuous-time version, $X\, e^{-rT}$. This changes as follows when we bring in dividend-yield, q, into picture: $[C - P + PV(X)]\, e^{qT} = S$. But, these are only applicable to the European options on non-dividend-paying securities. For American options on non-dividend-paying stock, only the following inequality is shown to be satisfied: $C - P + PV(X) < S < C - P + X$. So, in the simplest model, We can derive the PCP (put-call-parity)-Implied spot-price as follows.

$$S = C - P + X/(1 + r) \qquad \text{….. (2)}$$

where r is the interest rate between the trade-date and the option’s maturity-date.

3. Indian Institutional Framework

3a. Brief Description of NSE and BSE and Their Price Determination Processes

Bombay Stock Exchange Limited (BSE) was established as "The Native Share & Stock Brokers' Association" in 1875. It was the first stock exchange in India which got permanent recognition on 31 August 1957 under the Securities Contract Regulation Act, 1956. In the olden days, the meetings of the stock-brokers took place under banyan trees in front of the Town Hall in Mumbai. Ten years down the line, they shifted to the shadow under another set of banyan trees, the one at the junction of Meadows Street. Hence, SEBI's silver-jubilee publication by Malik et al (2013), which chronicles the evolution of the Indian stock-market through the ages, is aptly titled *Banyan Tree to e-trading*. As the number of brokers multiplied, so did the required square-feet for their meeting-place. Finally, in 1874, they found their 'own' permanent place, appropriately christened the Dalal Street (Brokers' Street). The Exchange launched the very first equity-index of the country, the S&P BSE SENSEX based on 30 shares, on 2 January 1986. Its base year was taken as 1978-79 and the corresponding index level on 1 April 1979 to be 100.

Upon request from the central government, some leading financial institutions of the country got together to form the National Stock Exchange Limited (NSE). Interestingly, it was incorporated in November 1992 as a tax-paying company, the path not followed by any other stock-exchange of the country. In April 1993, it got recognition as a stock-exchange as per the Securities Contracts (Regulation) Act, 1956. It commenced operations in the Wholesale Debt Market (WDM) segment in June 1994 and in the Capital Market (Equities) segment in November of that year, while operations in the Derivatives Segment commenced much later, only in June 2000.

In India, the Futures and Options (F&O) trading system provides a fully automated trading mechanism. It provides a screen-based trading – doing away with floor-based system - on a nationwide basis. It has a surveillance mechanism backed by online monitoring, which also facilitates transparency of trading operations in this order-driven market. As and when orders are received, they are time-stamped and immediately process it for the best potential match. Any unmatched order is carried in different 'books' as per price-time priority.

The best buy order matches with the best sell order. It is possible that an order would match partially with another order, requiring more than one trade for the order to be fully satisfied. The matching mechanism looks at the buy orders from the seller's perspective and the sell orders from the buyer's perspective. So, the best buy order is the one with highest price, while the best sell order is the one with lowest price.

Members may feed in buy and sell orders to the online system. An order is displayed on the screen till it is fully matched by a 'counter-order' and results into one or more trades. Or, a member may watch the existing orders in the system and place an order reactively that matches partially or fully with them. Orders that are not matched are called 'passive' orders, while those that are placed in to match the existing orders are called 'active' orders. To ensure that orders that come earlier get higher priority than those that come later, matching always takes place, naturally, at the price of the passive order.

3b. F&O (Futures and Option) Segments in India

Equity-Derivatives trading took off in India in June 2000 following approval by the *Securities and Exchange Board of India* (SEBI) on the basis of recommendation of the LC Gupta Committee. The derivative segments of NSE and BSE were permitted to start trading and settlement in approved derivatives contracts with the involvement of their clearing house/corporations. Initially, SEBI approved trading in futures contracts based on different equity-indices, such as prominent ones like NSE's S&P CNX Nifty and BSE's Sensex. Later on, option- trading was permitted in indices as well as individual securities.

BSE started the first exchange-traded index-derivative in India on 9 June 2000. The inauguration of trading was done by Professor JR. Varma, Member of SEBI and Chairman of the committee that formulated the risk-containment measures for the derivative-market. Then followed a series of innovative-product launching: Sensex-Option 1 June 2001, Equity Options (on 31 stocks) on 9 July 2001, and Equity (or Single-Stock) Futures on 9 November 2002.

NSE was not behind. It started futures on its popular flagship index, S&P CNX Nifty, on 12 June 2000. Trading in Nifty Options followed on 4 June 2001. It then went ahead with Equity Options (on individual securities), edging past its closest competitor, BSE, by only a week to became the first exchange in India to launch equity-option. Single-stock futures were introduced on 9 November 2001.

3c. Some Descriptive Data about Indian F&O Segments

As delineated above, equity derivatives started trading in India in June 2000. At present, there are three exchanges which offer equity derivatives trading in India, namely NSE, BSE and the new entrant, MCX-SX, which commenced operation only in 2013. Equity-derivatives market, containing derivatives on both indices and individual stocks, has witnessed a phenomenal growth in India. As Table-1 shows, the average daily turnover has increased from 420 crore rupees (equivalent to 4,200 million or 4.2 billion rupees) in 2001-02 to 1,55,408 crore rupees in 2012-13, implying a compounded annual growth rate (CAGR) of more than 70%.

4. Review of Relevant Research

4a. Review of Literature on MM and PD

There have been numerous studies around the world about MM of derivative-markets in general and their roles in PD in particular. The reason is simple. Since many potential buyers and sellers hedge their positions in the futures or option market, it is believed that these markets convey information to the spot market that it would not otherwise have. Moreover, trading costs are typically lower and liquidity higher in the futures market. So, it is natural for researchers to explore whether this indeed is the case with different derivatives – futures and options in particular - in different countries at different points of time. There are various possibilities when multiple markets – say, as in here, spot and derivative markets - exist. The prices in the two markets can be completely independent (typically when there is no communication) or fully integrated (when there is perfect two-way communication); in most cases, it would be a mixture of the two, the usual scenario being that there is a dominant market where the price is discovered and price-specific information is then relayed to the satellite market. It is also likely that there is bi-directional causality where information flows from each market to the other, though with the possibility that one market is still dominant in this.

The survey by Madhavan (2000) on MM, though a bit dated now, provides an excellent insight into the initial theoretical and empirical research in PD. He categorises MM research into four broad categories. The first one is on price-formation and PD, which study determinants of trading costs as also the process by which price gets to reflect information over time. The second branch, on market-structure and design, focuses on how trading-protocols affect liquidity and market quality and thus price-formation. Information and disclosure, the third category, addresses transparency issues and analyzes the ability of the market players to observe information about trading process. Issues arising from the interplay between MM and other finance areas like corporate-finance, say that about the under-pricing of initial-public-offerings, come under the ambit of the fourth category.

In one of the earlier theoretical models with practical implications, Smidt (1971) argued that, in addition to what Demsez (1968) had modelled, the market-maker, in her quest to constantly bring her inventory up or down to a desired level, would influence price, thus making it depart, during the course of a day or sometimes even over a longer period, from the true value. But, it is Garman (1976) who formally modelled the relation between dealer's quote (or bid-ask spread) and the inventory level. One of the model's implications is that a dealer having a sizeable long position in inventory would not go for addition unless there is a drastic price reduction. Models by Stoll (1978) and Amihud and Mendelson (1980) reflect the intuition of the Garman model.

Mayhew (2000) made a more focused, though quite detailed, review of theoretical and empirical work on the effect of introduction of derivative on the underlying cash market, including PD. He points out that a simple way to analyze PD is to look at the led-lag relationship between spot and derivative market of an asset. Kawaller, Koch, and Koch (1987) took one-minute-interval spot and futures data for S&P-500 index for 1984-85 and found that the futures leads the spot market by 20-45 minutes, with longer lead in the more active nearer term contracts, but the spot market leads only by a maximum of two minutes. Realizing that asynchronous trading could be showing the spot-market as lagging, many authors try to overcome the problem. Harris (1989) examined the S&P-500 spot and futures data in five-minute-intervals ten days around the US stock-market crash of 1987 and concluded that, though the extreme movements in the cash-futures basis was caused due to infrequent-trading, even after correcting for that, the futures market still led the cash (or spot) market. Also using five-minute-interval data from April 1982 to March 1987, Stoll and Whaley (1990) overcame the infrequent-trading problem by making the spot return pas through an ARMA filter; they also found that the futures market leads by 5-10 minutes and sometimes cash market also leads, but the incidence of the latter effect is diminishing over time. Chan (1992) looked at the 20-share MMI index, which is less subject to infrequent trading, and both MMI and S&P-500 futures contracts. He also found strong support for futures leading spot and weak support for the reverse. In fact, he also observed that the index-futures led even the most-active component-stocks that are a part of the index. He also highlighted that the lead-lag relationship is not affected whether good or bad news is received or whether market activity is high or low. In an insightful paper, Wahab and Lashgari (1993) pointed out that earlier empirical works were misspecified, because they failed to recognize that the spot and derivative prices were cointegrated.

While Kamara, Miller, and Siegel (1992) have found no increase in spot-market-volatility due to introduction of S&P-500 futures, Antoniou and Holmes (1995) have argued that the introduction of stock-index futures increased spot-market volatility in the short run, but not in the long run. Frino, Walter, and West (2000) used high-frequency data for Share-Price-Index futures contract on Sydney Futures Exchange from August 1995 to December 1996 and analyzed the effect of release of macroeconomic and stock-specific information on the PD process in the spot and futures market. They found that the lead of the futures market strengthens significantly around the time of release of macroeconomic information, which is consistent with a scenario where investors with superior information on the broad market are more likely to trade in the index futures. There was also some evidence that the lead of the future market weakens and that of the equity-market strengthens around the release of information specific to individual stocks, consistent with a scenario where investors with stock-specific knowledge prefer to trade in underlying shares.

In one of the more recent studies, Tse, Bandyopadhyay, and Shen (2006) consider three different derivatives on the DJIA (Dow Jones Industrial Average) index of US and observe that they contribute to different extent to the PD process; they verify their findings by taking derivatives on S&P 500 index and conclude that multi-market leads to better efficiency in PD. Chen and Chung (2012) find that introduction of options on SPDR (Standard & Poor's Depository Receipts Trust Series I) has contributed an improvement in the quality of the underlying SPDRs by augmenting liquidity and facilitating PD. In an interesting study, Xing, Zhang, and Zhao (2010) report that, in US, stocks underlying options with the steepest volatility-smile underperform those underlying options with the flattest smile by 10.90% per year, after adjusting for risk. The former also suffer the worst earnings shock in the subsequent quarter. This is perhaps because traders with unfavourable news trade out-of-the-money puts, and equity-market is slow in impounding information contained in volatility-smiles.

As mentioned, such studies have been carried out all over the world. Kenourgios (2004) analyzes the relative movements in Greece's FTSE/ASE-20 index and the three-month futures on it and finds two-way causality. A survey by Lien and Zhang (2008) argues that, while there is clear evidence for the PD role of futures market in emerging markets, its price-stabilizing role cannot be established unequivocally. Schlusche (2009) analyzes the German blue-chip index, DAX, and, using Schwarz and Szakmary (1994) procedure, concludes that futures market is the most significant contributor to the PD process; he also highlights that, instead of liquidity, it is volatility that is the key for the PD leadership.

4b. Study of Derivative Exchanges

Tsetsekos and Varangis (2000) conducted a survey among almost all the derivative exchanges that were in operation in 1996: 75 in all. They made some important observations. As against the traditional approach of starting with derivatives on agricultural commodities, emerging markets have begun their innings with index-based and interest-rate-based derivatives. They also find that emerging markets introduce index derivatives more quickly than do their industrial counterparts. Most exchanges reported using the open-outcry system, though there is a discernible shift towards electronic-trading, which is the choice for the more recent entrants. Two-thirds of the exchanges had their own in-house clearing facility, but a recent tendency has been towards a common clearing for a group of exchanges; besides, most were self-regulating bodies owned by their members. Using "changes in consumer prices, prime interest rates, government bond yields, industrial production, growth in real gross national product (GNP), the level of GNP, and the share of investments in GNP" as economic proxies and "stock -market turnover and capitalization, the variance in stock -market capitalization, the value of stocks traded, the volatility in value traded, and the number of listed companies in the stock exchange" as capital-market-condition proxies, they did not find any statistically significant variable among these to make a country or market 'derivative-exchange-ready'.

Treviño (2005) analyzed 1999-2005 data for 83 derivative exchanges in 58 emerging-markets and, based on volume of contracts, inferred from the Hirschman-Herfindahl Index that the smaller exchanges have increased their market-share from 9% to 37% during this period. They also observed that most of the new-born derivative exchanges have focused on financial derivatives with or without commodity derivatives while the older one started with the latter type; this is partly because financials attract higher liquidity than commodities. They also point out that, in order to separate trading-rights from membership-rights, so s to allow outside ownership of bourses, derivative exchanges have undergone demutualization. They also discovered that interest-rate derivatives commanded the highest dollar-volume in both exchanges and over the counter (OTC) market, followed by equity-linked ones in the exchanges and foreign-exchange-based ones in the OTC.

4c. Brief Review of Literature on F&O on Commodities in India

Using 2005-2010 crude-oil spot and futures data in a US, a UK, and an Indian exchange, Goyal and Tripathi (2012) find Granger causality between spot and futures markets and conclude that PD mostly occurs not in the emerging exchanges but in the mature exchanges, where spot leads future. Using daily spot and futures prices of some agricultural, metal, and energy products during 2003-2011, Sehgal, Rajput, and Deisting (2013) find that the futures market plays the dominant role in the PD process. But, volatility-spillover is not present for most commodities, suggesting the absence of an efficient risk-transfer-system.

4d. Review of Literature on F&O on Nifty and Individual Stocks in India

In one of the first studies in India on its financial-derivatives market, Gupta (2002), using 1998-2002 data on Sensex and Nifty and corresponding futures data from 2000 to 2002, found that the volatility in futures market is not necessarily higher than that in the spot market and the introduction of futures in fact led to a reduction in spot-market-volatility. They, however, caution to take the latter observation in the right perspective, as other microstructure changes like closing-down of the 'badla' system and curtailment in the trading-cycle took place following the introduction of the above-cited derivatives. Analyzing the daily data on BSE Sensex and NSE Nifty, as well as the broad-based BSE-200 and Nifty Junior, from January 1997 to March 2003, Bandivadekar and Ghosh (2003) also concluded that volatility reduced in both the Indian exchanges in the wake of the introduction of index-futures in 2000. They also observed that, while the reduction in Sensex's volatility captures only the market effect, that in Nifty's both market and the derivative effect – the effect of introduction of futures. Raju and Patil (2002) found that time-varying volatility is exhibited by some Indian equity indices. To examine the effect of expiration-day of options and futures on price, volume, and volatility of the underlying spot, Vipul (2005) took 2001-2004 data, within one day on the either side of the expiration, on 14 NSE stocks that had derivatives trading on them. Using nonparametric test, he found that the share-price tends to go down the day before expiration of its derivative contract and strengthen the day after, with this increase much higher for those shares whose derivatives trade in higher volume compared to their spot. Pandian and Jeyanthi (2009) took 1998-2008 data for BSE Sensex and NSE Nifty and found that bull phases had lower volatility than bear phases. Saravanan and Deo (2010) analyzed the spot and futures prices of Nifty during 1996-2007 and found that introduction of derivative reduced, though only marginally, volatility in the spot market. They feel that presence of uninformed traders in the derivative market may be inducing volatility in that market, which may lead to lesser reduction in volatility in the spot market than would have been observed if only informed traders played in the derivative market. They, however, observed that, following introduction of derivatives, spot-market volatility reacted less to old information and took this as a sign of increased efficiency. They argued that, the positive relationship between volume and price volatility implies that a future contract would be successful only if there is considerable uncertainty associated with the underlying asset. Sakthivel and Kamaiah (2010) took 2000-2008 daily closing prices of Nifty and the three Nifty futures: near month, next month, and far month. They found that there is a long-term relationship between the spot and futures markets and that there is bidirectional volatility spillover between these two markets. Pati and Rajib (2010) took 2004-2008 data for Nifty futures and, using ARMA-GARCH and ARMA-EGARCH models with GED distribution, and discovered time-varying volatility as had other earlier research. Agarwalla and Pandey (2013) took high-frequency data during 2001-2009 for 307 NSE stocks which are either index stocks (part of an NSE index which had derivatives trading on them), or futures stocks (which had futures trading on them), or were both, and, in addition, 300 other most liquid stocks. They found that both futures-stocks and index-stocks experience higher volatility during the last thirty minutes of the expiry of their relevant derivative contracts, with the higher magnitude for the futures group. They also report different intraday volatility pattern for futures stocks, which they think may be due to parallel PD in their futures markets. Interestingly, they conclude that the cash-settled nature of the stock-futures induce high volatility in the spot market during the futures's trading period.

Raju and Karande (2003) is one of the earliest studies on PD of financial derivatives in India. Using Nifty futures data from June 2000 to October 2002, they have also found that its introduction has brought down the volatility in the spot market. Further, they find that, while there was no causality till August 2001, there was bidirectional causality from September 2001 onwards (with PD occurring in both the spot and the futures markets). Bose (2007) took daily closing prices during 2002-2006 for Nifty spot and futures to study the PD process. She concludes that, in the short-run, the futures market - which adjusts faster to new information and absorbs most of the consequent volatility - leads the spot market; but, in the long-run, the information-flow is bidirectional, though futures does have a slight edge. Karmakar (2009) used daily data from June 2000 to March 2007 for Nifty spot and the near month contract for Nifty futures and analyzed their relationship using a Vector ECM (Error Correction Model). They found that, though the causality is bidirectional, futures price affects spot price more than the other way round. In fact, while the futures market information continues to flow to and affect the spot market right from day 1 till day3, the spot market's effect on futures market is felt only on the third day. They had found log prices of both spot and futures to be non-stationary, but corresponding returns to be stationary. Pradhan and Bhatt (2009) took daily closing spot and futures (near month contract) prices of Nifty from 2000 to 2007 and studied the PD process. They found that PD takes place mainly in the spot market, which functions as the dominant market and leads the futures market. But, Srinivasan (2009), who analyzed Nifty daily spot and futures data from 2000 to 2008, found that there is a bi-directional causality between the spot and futures market. Mukhtar (2011) used daily closing values of Nifty and its futures from June 2000 to November 2008 and found that PD occurs in both spot and futures market, though the latter has greater speed of adjustment towards equilibrium; bidirectional causality is also discovered. Sadat and Kamaiah (2011) used data on 42 NSE stocks of high market-capitalization and found abnormal volume and price-change on days just prior to expiration-day of the related futures contract. Choudhury and Bajaj (2013) used 2000/2001-2010 data on daily spot and futures prices of individual stocks and found that futures price leads the spot in case of Nifty and 21 stocks and is led by spot in case of 20 stocks.

With the availability of high-frequency intraday data, it has become quite insightful to use these, though analyzing them over a long horizon can pose considerable computational challenge. Reddy and Sebastin (2008) took high-frequency data on Nifty and its near-month futures from October 2005 to September 2006 and analyzed the information-transmission process of PD using the information-theoretic concept of entropy. They found that information flow from futures to spot is more pronounced than that from spot to futures. Debasish (2009) used high-frequency data for 2001-2008 for Nifty as well as futures and options written on it. He found that the futures market leads the spot market, though its dominance is diminishing over time. He also found the option market to be overall leading the spot market, though sometimes it reverses, implying feedback. Interestingly, he also argued that the Nifty call leads the futures more than the converse, whereas futures leads put more than the opposite. He clarified that, since his study covered a reasonably bullish period, which might have attracted more activity in the Nifty call market, this could have been observed; this belief is backed by the stronger lead of call over put during that period, though it is a puzzle why the two instruments with the same trading-costs should at all have a lead-lag relationship. Gupta and Singh (2009) took intraday (five minutes' interval) spot and futures data on Nifty and the 50 most liquid stocks in NSE from April 2003 to March 2007 to study the PD process. They found that, though PD takes place in both spot and futures markets, it is the futures market that strongly Granger causes the spot market. Interestingly, they find that, though the difference between the spot-price-implied-futures-price and the actual futures-price does not vary much for Nifty as the maturity-date is approached, the difference increases for individuals stocks, contrary to what most other studies find. Mallikarjunappa and Afsal (2010), using minute-by-minute data during July-December 2006 for twelve most liquid stocks, find that a contemporaneous and bi-directional lead-lag relationship between the spot and futures market, thus without any dominance by either of the markets.

Aggarwal and Thomas (2011) took minute-by-minute data from March to August 2009 on 97 stocks and their near-month futures trading in NSE. They also took price-impact (from the limit order books) as the measure for liquidity. They conclude that liquidity in futures market plays a pivotal role for its dominance in PD and only when a stock's futures market is illiquid does its spot market play a leading role here. They also find that the futures market plays a more important role when there are large price-movements. Agarwalla, Jacob, and Pandey (2012) took high-frequency volume, volatility, and price data from July 2010 to June 2011 for the fifty stocks in NSE Nifty as on 18 October 2010, the day NSE reintroduced pre-open call-auction for these fifty large-capitalization stocks, perhaps with a hope to facilitate PD relating to them. Using the correlation between overnight-return and subsequent returns as a measure of the call-auction's ability towards improving PD, they concluded that there was no such 'good news'; they conjecture that the short duration of the call-auction may be the reason behind this. The press also points out that the absence of continuous trading leads to the traders' failure to get an adequate idea about the price structure and thus makes PD difficult (Shah and Mascarenhas 2013). They, however, found that price synchronicity – the ability of the pricing model used to explain the actual variations in stock returns - improves after the introduction of the call auction, which typically is not expected to have any impact on the PD during the day, especially for the highly liquid stocks. Choudhury and Bajaj (2012) took high-frequency NSE spot and futures data from April 2010 to March 2011 on 31 stocks and found that there was bidirectional information flow between spot and futures market among 30 of them, with Wipro being the sole exception, having the flow only from spot to futures. They also concluded that futures leads spot in case of 12 of them and the reverse happens in case of the rest.

Some researchers have tried to look at the information-conveyance power of option-prices from a different perspective. Srivastava (2003) used data from November 2002 to February 2003 on 15 most liquid stocks of NSE and options on them and analyzed, using the methodology developed by Bhuyan and Chaudhury (2001), the power of open-interest and volume to predict the underlying spot price. He found both the variables to have significant explanatory power, with open-interest being more significant. He also found that option-market helps in the PD process in the underlying cash-market. Mukherjee and Mishra (2004) used daily spot prices for only Nifty and option-prices as well as open-interest (OI) and trading-volume (TV) for all the available strike-prices of the nearest month Nifty option for two sets of periods: June-December 2001 and January-June 2004. They found that, though TV had no power in the beginning – just after Nifty option was introduced - to predict the movement of later spot prices, it became quite significant at it, towards later periods, even more than OI, which itself also moved from being significant to more significant towards the later part. They further discovered that, the combined efficiency of OI and TV is higher than the sole efficiency of each of them. Overall, the index option market improves its power of PD in cash market. Sehgal and Vijaykumar (2008) took daily data during 2004 and 2005 for number of contracts and traded-value of the most frequently-traded 38 stocks out of 51 in that had calls and puts available on them in NSE. They found that both these option-liquidity proxies are positively correlated with stock price, stock return volatility, and stock liquidity and negatively related to the firm size, which the authors took as a proxy for the uncertainty in the information environment. Taking traded-value (TV) and net-open-interest (NOI) data for options on Nifty and 15 NSE stocks from November 2001 to November 2004, Srivastava, Yadav, and Jain (2008) analyze the power of these two variables to predict the underlying spot price. Using the above-cited methodology followed by Srivastava (2003), they found that, for Nifty, call and put NOI-based predictors are significantly positive and negative, respectively, while call and put TV-based predictors are both significantly positive but not as prominent as the NOI-based ones. For stocks, NOI-based predictors exhibited the same characteristic in ten cases, with TV-based predictors not showing any consistent signs. But, a study by Pathak and Rastogi (2010) shows that both NOI and TV are relevant for the purpose.

The role of STT in the derivative market has attracted attention from some resaechers. Slivka, Aggarwal, Shastri, Sisodia (2012) took eight of the stocks which had liquid futures contracts in NSE, with half each from bank and IT sector. One trading day in each of the months from June 2011 to December 2011 was chosen, with the near month (same month in this case) contract expiring in 20-24 days. Matching the timing of the spot and futures trade to the same second, potential arbitrage profits were calculated, using different STT. The study concluded that a reduction of 75% in STT was required to achieve any meaningful arbitrage opportunities.

5. The Current Study

5a. Data Sources

Nifty futures started in June 2000 and Nifty options in June 2001. (Single) Stock Options began trading in July 2001 and futures in November 2001. But, we dropped every derivative's first month, as it exhibits very high volatility. To be able to compare spot, futures, and options over the same period, we wanted synchronous data for all these three contracts on Nifty and the ten selected stocks. Therefore, given that the last among the above-cited derivatives was introduced in early November 2001, our study period starts on 1 December 2001. The exception was, of course, BPCL, whose equity-options started in January 2002. So, for this, the starting date was 1 February 2002, though ending still 31 December 2012, as it is for all.

We collected the closing-price data for the above period for spot, futures, and options (on Nifty and ten stocks). The ten stocks were randomly chosen. All data on these eleven securities (that is, Nifty plus ten stocks) were obtained from NSE. We also collected the 2001-2012 risk-free-rate (the 91-day TB auction cut-off-yield) data from the website of RBI (Reserve Bank of India).

The study period from December 2001 to December 2012, which is a month more than eleven years, was broken down into the following seven sub-periods.

SP-1 → Subperiod-1) NS (No STT): 1 December 2001 to 30 September 2004
SP-2 → Subperiod-2) PS (Post STT): 1 October 2004 to 31 May 2008
SP-3 → Subperiod-3) IS (Increased STT): 1 June 2008 to 31 December 2012

The choice of these cut-offs was dictated by the dates for introduction and subsequent change in India's Security Transaction Tax. Security Transaction Tax (STT), payable *inter alia* on the value of purchase or sale of selected securities including futures and options, came into effect on 1 October 2004 and became payable by the futures-seller at a rate of 0.01% of the futures-price and by the options-buyer, only if she exercises, at the same rate on the strike-price. On 1 June 2008, it became applicable also to premium received on option sales at a rate equal to that on futures sales, which had changed on 1 June 2006, along with the rate payable at exercise of options, to 0.017%; moreover, on that date, the rate payable at the exercise of options shot up to 0.125%.

5b. Methodology

Kenourgios (2004) outlines the basic procedure that we need to follow before we embark on the more complex part of the PD analysis. We first need to test for stationarity in the level, as well as in the first difference, of the spot price and the other prices (whether futures price or option-prices-implied-spot-price) the Augmented Dickey Fuller (Dickey and Fuller 1981) test - ADF test in short -. For the first-difference, the equation for the spot-price would look something like the following, if we believe that the order of lag would be at most two, as is found in many economic time-series data.

$$\Delta S_t = \alpha + \beta t + \rho\, S_{t-1} + \gamma_1 \Delta S_{t-1} + \gamma_2 \Delta S_{t-2} + u_t$$

If $\rho = 0$, then we cannot reject the null hypothesis of a unit root which implies a random-walk process for the variable. It is quite possible that the variable is non-stationary at level but stationary at first-difference. Anyway, the problem with ADF test is that it does not allow any serial correlation or heteroskedasticity. To overcome this problem, we would also employ the Phillips and Perron (1988) test – PP test in short - which is relatively robust even when there is serial correlation and heteroskedsticity. The above equation should be tested separately for both the spot and the other prices mentioned above, each of which is represented above generically as S_τ.

It is quite possible that there is some systematic characteristics in the lead-lag relationship of derivative and spot markets for different underlying assets or indices. If that is indeed the case, it may be wiser to test simultaneously for the direction of flow of information between spot and derivative market.

If a long-run relationship exists between the spot (represented as S) and derivatives (whether futures price or option- implied-spot-price and represented as F) markets by price-changes in one market causing price changes in the other, we could, following Kenourgios (2004), present the relationship as follows.

$$\mathbf{F_t - \delta_0 - \delta_1 \, S_t = \varepsilon_t}$$

If either spot or derivative price-processes are non-stationary, Ordinary Least Square (OLS) regression cannot be applied. If both are non-stationary in such a way that the error term is stationary, then, as pointed out by Engle and Granger (1987), derivative and spot price processes are cointegrated, and they have an equilibrium relationship. Their co-integration implies that derivative and spot prices are integrated of the same order, which can be inferred from the unit-root-test described earlier. If the spot and derivative prices are non-stationary, but their first-differences are stationary, then the prices are effectively cointegrated at level (1,1), denoted as CI(1,1), with d1 being the cointegrating coefficient.

To test for co-integration, we would resort to, as Kenourgios (2004) does, Johansen-Juselius procedure. We did not use any Vector Error Correction Mechanism, because of discontinuity in some data. Our set of equations is as follows.

$$\Delta S_t = \alpha_1 + \sum_{i=1}^{n} \alpha_{11}(i)\, \Delta S_{t-i} + \sum_{i=1}^{n} \alpha_{12}(i)\, \Delta F_{t-i} + \sum_{i=1}^{n} \alpha_{13}(i)\, \Delta O_{t-i} + \varepsilon_{S_t}$$

$$\Delta F_t = \alpha_2 + \sum_{i=1}^{n} \alpha_{21}(i)\, \Delta S_{t-i} + \sum_{i=1}^{n} \alpha_{22}(i)\, \Delta F_{t-i} + \sum_{i=1}^{n} \alpha_{23}(i)\, \Delta O_{t-i} + \varepsilon_{F_t}$$

$$\Delta O_t = \alpha_3 + \sum_{i=1}^{n} \alpha_{31}(i)\, \Delta S_{t-i} + \sum_{i=1}^{n} \alpha_{32}(i)\, \Delta F_{t-i} + \sum_{i=1}^{n} \alpha_{33}(i)\, \Delta O_{t-i} + \varepsilon_{O_t}$$

The above first-difference VAR (vector autoregressive) models can be estimated with OLS method. In any case, if two markets (or instruments) cointegrated, then causality must exist in at least one direction and can, of course, be bi-directional too (Granger 1986). For example, if some α_{12} above are non-zero and all α_{21} are zero, then the futures market is the dominant market and the spot market satellite. Similarly, for the spot market to lead the option market, we have to have some α_{31} non-zero and all α_{13} zero. On the other hand, if all the above sets of variables are jointly and severally non-zero, there is a bi-directional relationship, while, if they are zero, there is independence.

But, as Goyal and Tripathi (2012) point out, the above error-correction-mechanism does not capture contemporaneous correlation, for which they supplement their tests with a test advocated by Phillips, Wu, and Yu (2011) for short-term collapsing asset-price bubbles that are not picked up by unit-root and co-integration tests. We do not reckon that test to have been extended to financial derivatives too; but it may throw some useful regulatory insights. We have, however, not employed that here.

5c. Results

For all the futures series, we chose the most active future contract on each date; but in case the most active contract was maturing on that date, we took the second most active contract, as the volatility on expiration-day of derivative-contracts has been reported to be quite high by many studies. Then, we take three spot prices: the actual spot price, the futures-price, and the put-call-parity-implied spot-price ('option-implied-spot' hereafter) derived from the option prices using equation-2 above. We ran some analysis using the spot-price as implied by the futures-price and *prima facie* seemed to find the results to be not too dissimilar; but more analysis there is warranted.

Then, using both ADF and PP tests, we analyzed the stationarity of their natural-log values and found that all series are non-stationary. So, we took the first-difference of the log-values and, again using ADF and PP, found them to be stationary. Table-2, which presents some descriptive statistics and the Jarque-Bera p-values, also presents the ADF and PP p-values to highlight this. The table presents the information for the full period, as well as the three sub-periods. It is interesting to note, which is not unusual and not at all unexpected here, that the standarddeviations of the level are quite close for the three contracts: spot, futures, and option-implied-spot. Of course, we are effectively dealing here with three surrogates of the spot-price, though it is a bit less so when we are taking the futures-price instead of the futures-implied-spot price.

Table-3 presents the average annual volatility for each year and as also for the sub-periods (non-standardized). It does not fully corroborate what previous research says: that spot-market volatility has fallen following the introduction of derivatives. Though the changes have been inconsistent across years and stocks, some general observations can be made. In the first year after introduction of derivatives, that is, in 2001, spot volatility fell for almost all, though not all, of our stocks. But, as expected, the volatility of Nifty and the individual stocks was quite high in the post-meltdown era of 2008 and 2009, which also reflected in high volatility in SP-2 (subperiod-2). What is more interesting, however, is that volatility fell appreciably thereafter. By 2012, for the spot contracts, it had fallen to quite a low level, almost compared to the 2001-level for the majority and thus, for most, was lower than the level of the year preceding the introduction of the derivatives. But, comparison of the 2012-level with the initial years after the introduction of derivatives shows volatility to have increased for many futures and option contracts.

Having realized that our first-difference series (of log values, of course) are stationary, we checked, using Johansen-Juselius procedure with a linear-trend, whether spot, futures, and option-implied-spot are cointegrated. The Table-4 overwhelmingly shows that they are. Thus, despite their non-stationary nature, derivatives and spot markets exhibit a long-term relation. This exists also between futures and options on individual stocks, a relationship none had hitherto studied in the Indian context. But, the table also highlights that, at a five percent level of significance, there are typically at most one cointegrating equation. One simple – rather simplistic – way of stating it is that the long-term relation between our spot, futures, and option contracts is somewhat unique. This led us to study the causality between these three contracts: spot, futures, and options. As Table-5 shows, there are causalities in various directions for the different stocks and even for the same stock over different sub-periods. To get a more cohesive picture of it, we came up with a simple and novel way of summarizing the information, which is presented in Table-6. Panel-A presents information for basic causality, whether one affects the other, independent of whether reverse causality exists or not. Clearly, the effect of F (futures) and S (spot) on O (Option) is the main significant observation, if we ignore the frequencies of independence. Panel-B captures whether the causalities are unidirectional or bi-directional. Here also, we see that the influence of F on O is quite high in the beginning, but falls drastically by SP-3 (subperiod-3). But, the influence of S on both F and O becomes more pronounced by the last sub-period or remains at the earlier high level. Panel-C, again taking the information in the way Panel-A took, shows the information in what we may call the NR (net run rate) format: how one of the three influences the two others. Here again, barring the high frequency of "no causality", we find that the strong influence of S on the two others (F and O) has gotten stronger over time, while that of F on the others has gotten weaker over time. Panel-D puts the perspective in the same light as Panel-B had done. It shows that there is more independence than bidirectional causality. But, when it comes to one-way causality, it tells – quite consistent with its preceding panel - is that, S's influence on the two others has appreciably gone up over time, while that of F on the others has somewhat fallen. Though our approach here is, we think, quite innovative and insightful, these findings are not very inconsistent with other findings that futures and options lose their dominance on spot-market over time, but here, the derivative-markets have mostly been satellites and become more so over time.

The next table, Table-7, presents the causality analysis for the full-period from two different perspectives: the full period as a whole and the overall findings for the three-subperiods. Panel-B highlights the influence of S on F and O and that of F on only O. Panel-C corroborates that, but brings in two newer insights not thrown in by our earlier tables. It shows that, in the twelve-year period as a whole, O also had influence on the two other contracts and that each of the derivative contracts has bidirectional causality with the other derivative and the spot. This finding should alert us to the fact that analysis based on long intervals may have conclusions quite different from what the short periods would more effectively bring out. Similarly, Panel-E tells us that, based on the combination of the three sub-periods, we would tend to infer that S's dominance over the derivatives has increased over time, while the full-period analysis – which, of course, cannot suggest anything regarding the trend in dominance – would find S's dominance over O to be the only significant conclusion. Panel-F regarding the trend in dominance – and, therefore, naturally, only for the subperiods – wraps it up succinctly: only the dominance of spot has increased significantly over time. This should make us analyze why the derivatives markets have failed to dominate, though they are often desired to.

Though a reasonably clear picture regarding the increasing dominance of S and lacking or falling dominance of F and O has been emerging from the above analysis, we deemed it appropriate to complete the analysis by doing a VAR (variable auto-regression) analysis, which investigates whether past levels – whether price or return - of O, F, and S affect the current values of the two others (and, less interestingly for us here, its own current values). Table-8 presents the analysis along with the significance-indicator of the coefficients (an asterisk, '*', implies significance at the five percent level). To make more sense of these numerous figures, we summarize them in Table-9. The full-period analysis highlights what we should have expected: past levels of S affect current the level of each of F and O and past levels of F affect the current level of each of S and O. Again, as somewhat expected, F's influence has diminished a little bit by the last sub-period, while that of S has increased slightly. Just to see whether the above findings anyway translate into trade-value of the three contracts, we computed the annual trade-value across the years. Table-10 shows that the trade-values (TV) of the single-stock futures and options have been steadily increasing over time. When we take futures TV as a percent of the spot TV, we find that, in recent years (and, in particular between 2011 and 2012), it has fallen in more than half the case, including that of the Nifty. During the same time, the TV of options as a percent of the TV of spot has increased for all the stocks in our sample, though it has marginally fallen for Nifty. Anyway, the TV of options as a percent of that of the futures has increased during that period for all our stocks as well as Nifty. This increasing popularity of stock-options despite their reducing efficiency in PD is bound to puzzle some.

Findings by Mishra and Mishra (2013), who have reported analysis of single-stock-options from a different perspective, may provide some answer. They computed the TV-weighted and OI (open interest) weighted average-strike-price - for calls and puts separately - for each trade-date and analyzed whether any of these four (Call-TV-weighted, Put-TV-weighted, Call-OI-weighted, or Put-OI-weighted average-strike-price) had any capacity for PD. They found that, during each of the sub-periods and the whole period, for each stock-option as well as Nifty, almost all of these were influenced by the spot and the futures. Moreover, for the single-stock options, none of these played any role in PD. But, for Nifty, interestingly, during subperiod-1 and subperiod-3, they found that almost all of these also influenced futures and options, thus causing bidirectional causality. During the whole period also, consistent with what some other researchers have found, the Call-TV-weighted strike-price, and only that, influenced futures and option, thus showing the capability for PD. Overall, these results are consistent with our earlier finding about the waning importance of single-stock options in the PD process. But, they somewhat countered the finding about Nifty option, which we had earlier reported to have bidirectional causality with futures and spot during the first two sub-periods, though it was fully dominated by them in the third sub-period as well as the whole period.

To look at the popularity of options more minutely, we focused on ATM (at the money) and NM (near money) calls and puts. ATM denotes the call or put with the strike-price exactly equal to the spot-price, but they were often not available. So, we took the call and the put with the strike-price closest to, which was not always necessarily equal to, the spot-price; these are NM options. We have put both ATM and NM under ATM. As Table-10 shows, the combined TV of the ATM call and put as a percent of the total TV of all options has shown a downward tendency in the recent years. Though it might be due to some reaction in the aftermath of the global meltdown, it might also be due to some institutional changes, like the Exchange switching from American stock-options to European ones or some relative change in the STT. So, in this light, an ‘experimental’ recommendation we may like to make – particularly to further encourage purchase of calls and puts, though only ones which are at or near the money - is as follows. That STT be reduced – if not waived – when an investor buys an ATM (at the money) or NM (near-money) put – where the strike price is equal to or close to the prevailing spot price – and exercises the put at expiration-date by selling his shares. Similarly, if an investor buys an ATM or NM call and exercises it at maturity, the same benefit should be extended to her if she buys shares on or just before the option-expiration-date. Whether and how to tax any profit from these ATM calls or puts are easier issues to debate.

5d. Conclusion

In this study, we took synchronous daily spot, futures, and option prices on Nifty and ten randomly selected stocks and found that, while the spot-market is increasing its dominance over futures and options, the futures market's dominance over option-market has drastically fallen following the increase in STT. The traded-value of the corresponding options, however, has increased over time. We propose a reduction or elimination of STT on purchase, for hedging purposes, at-the-money and near-money calls and puts that are accompanied by purchase and sell of corresponding shares at or just before the expiration date.

To our knowledge, this is the first study in the Indian context to a) analyze price-discovery (PD) in India's single-stock-options market using the information conveyed by the option-prices and compare it to PD in the corresponding futures and spot markets, b) simultaneously analyze the PD in spot, futures, and option for the individual stocks (ten of which were selected by this study), and c) analyze PD in the market for futures and options on these ten stocks and on Nifty during three different regimes pertaining to STT (Security Transaction Tax).

5e. Suggested Extensions

This study can be extended in many ways. First, instead of using put-call pairs only for inferring implied spot-prices, one should use all calls and puts, though it would be more complex and require stronger assumptions. Second, instead of studying options and futures on each individual stock separately, a panel analysis should be carried out. Sometimes, panel-analysis throws insights that are not available when studying them separately. Panel unit-root test is also sometimes considered superior to the standard unit-root test. Moreover, there have been very few, if at all any, panel-cointegration analysis to analyze equity and index derivatives in India. Third, more varieties of price should be brought in to picture. Using opening prices of different securities along with the closing prices used can throw more light on the lead-lag relationship relating to price-discovery between the three contracts under focus: spot, futures, and option. Then, of course, high-frequency data should be ushered into the picture. The only constraint with this kind of data is that, analyzing it over a long period – as we have done here for a comparative analysis over multiple subperiods – is a challenging task. Fourth, though this study broke-down the sample period to only three sub-periods; given that it spans the global-meltdown of the late 2000 and also microstructure changes in NSE (like replacement of American-style single-stock-options with European analogues from January 2011), a finer division of the full-period is called for based on those. Fifth, one should also use information conveyed by the traded-value and open-interest of the index and single-stock options to see if there is some price-specific information there that can facilitate price-discovery. In that light, it is worth coming up with measures of 'efficiency' of the derivative-markets other than in price-discovery or in leading spot markets.

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