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Option Pricing Experiments: Gaps in Stochastic Models, Scalability in Indian Contexts

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Abstract

Considering the Indian National Stock Exchange's growing prominence in international derivative trading, there is a pressing necessity for effective pricing mechanisms that are aligned with market realities. Thus, this study is crucial as it provides a systematic literature review of 195 studies on option pricing experiments conducted by various researchers in the past. These studies are obtained from various databases like Scopus, Google Scholar and Web of Science with keywords, "option pricing", "derivative pricing", "empirical", "non-parametric technique", and "parameter methods". It commenced with literature on pricing efficiencies of Black Scholes through some country specific studies. It then discusses the studies based on impact evaluation of crisis on pricing efficiencies globally. Followed by it is the extant literature with respect to deterministic and stochastic parametric models as well as cross model studies in parametric models and non-parametric techniques, which combine to formulate specific research gaps in the literature as well as methodologies used commonly for option pricing. Finally, the study provides a roadmap for resolution of these research gaps which can aid scholars and practitioners in developing more dependable, precise, and empirically proven option pricing models, ultimately improving the efficiency and stability of financial markets.

Keywords: Option Pricing Efficiency, Black-Scholes Model and Alternatives, Parametric and Non-Parametric Pricing Models, Financial Crises and Option Pricing

Introduction

A literature review on option pricing models serves multiple purposes. By providing a framework for option pricing, the Black-Scholes model transformed the field of financial derivatives, leaving a significant impact on both academic research and real-world trading strategies (Black & Scholes, 1973). Reviewing previous research on the topic helps establish a fundamental understanding of these groundbreaking contributions, while also highlighting the evolution of option pricing models.

Over time, several extensions and alternative models have been developed to address the limitations of the original Black-Scholes model, which includes assumptions of continuous trading, ideal markets, and constant volatility (Merton, 1973). A comprehensive review aids in identifying where these assumptions break down in real markets and where gaps exist in current models (Heston, 1993; Bates, 1996).

Different strategies for handling complex market behaviours are offered by models such as Heston's stochastic volatility model, Merton's jump diffusion model, Bates' extension of the Heston model, and deterministic volatility models. Understanding the development and relative advantages of these models provides valuable perspectives on their applicability to various market conditions (Heston, 1993; Merton, 1976; Bates, 1996).

Empirical research plays a crucial role in integrating theoretical models with real-world applications. By examining how these models are applied in different markets—such as equities, foreign exchange, or commodities—researchers gain insights into the functionality of these models across diverse conditions. This connection between theory and practice is especially useful for analysts, traders, and financial institutions (Jorion, 1995; Dumas et al., 1998).

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Recent advancements in artificial intelligence (AI), machine learning (ML), and computational techniques are pushing the boundaries of option pricing. Reviewing contemporary literature offers a forward-looking perspective on the development of new pricing models and helps researchers keep pace with cutting-edge methods (He et al., 2020).

A thorough literature review not only provides researchers with a solid theoretical and empirical foundation to contribute new insights or refine existing models, but it also aids practitioners in determining the most appropriate models for specific hedging, speculative, or risk management strategies (Gatheral, 2006).

By conducting a literature review, researchers can better position their work within the broader academic discourse, identify key challenges, and highlight areas for further exploration (Andersen & Andreasen, 2000). Therefore, the study was initiated with an extensive review of existing literature on option pricing models. This review focuses on both parametric models and non-parametric techniques, which are outlined in Table 1.

Methodology

This literature review (LR) will identify, analyze, and summarize the current experimental research related to option pricing. The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) framework was then put into consideration to improve transparency and reproducibility in the review process (Moher et al., 2015).

This Systematic Literature Review (SLR) aims to carry out a comprehensive review of experimental practices regarding option pricing in an endeavour to outline trends, methodologies, and key contributions arising from the several studies (Dube et al., 2014). The review intends to present an understanding of how experimental research in option pricing has developed over the years and bulked on such a large profile in the field.

For a thorough review, data sources were extracted from several academic databases such as Scopus, Web of Science (WOS), Google Scholar, EBSCOhost, ScienceDirect, and SpringerLink (Fitzsimmons et al., 2020). Boolean operators were vigorously applied to refine the search with keywords: "option pricing", "derivative pricing", "empirical", "non-parametric technique", and "parameter methods" to provide various studies considered relevant to the topic (Chen et al., 2017).

The set inclusion and exclusion criteria were carefully defined to facilitate the selection of studies applied in the review. The studies were included if they were conducted and published from 1970 to 2024 with respect to the experimental research of option pricing. These studies included peer-reviewed journal articles, conference papers, and working papers. The next constraint was set for publication language as English. Studies that were not peer-reviewed such as blogs, news articles, or other types of unpublished dissertations (Cheng & Ke, 2021) were excluded.

The identification and selection of studies were rigorously followed through a systematic screening process highlighted in the PRISMA flow diagram. From this search, 345 studies were initially found across various databases. After elimination of duplicate listings, a total of 260 studies were found distinct. This finally resulted into 215 studies that were subjected to further review. A screening of the full text of the 215 articles which fulfilled the inclusion criteria (Moher et al., 2015), yielded a final sample of 195 studies for the analysis.

Data extraction was done based on a predetermined coding scheme, analysing the study objectives, types of experimental methods, characteristics of the sample, model specifications, and main findings. Thematic analyses were employed to uncover trends in the literature, methodological advancements, and existing research gaps (Moffatt et al., 2017).

A thorough evaluation of the quality of the option pricing experiments was conducted. The assessment is focused on the strength of research designs, data quality and validity, and the studies' findings in relation to theory and practice concerning Option Pricing Experiments (Timmermann & Granger, 2004).

Information has been synthesized to provide a systematic review of option pricing experiments, addressing the contemporary issues and future opportunities. In reviewing the empirical data, observing the better suited option pricing models which provided insight into the classification and interpretation (Black & Scholes, 1973; Hull, 2017).

This SLR, which utilizes the PRISMA framework, allows for the objectivity and consistency of the review of literature on option pricing experiments, thus providing insights into current research and further research opportunities.

Discussion

The table below indicates the brief description of various option pricing models based on which the extracted research papers are based upon.

Table 1: Description of Various Option Pricing Models Reviewed

Category	*Type of Model*	*Model*	*Description*
Parametric	Deterministic	Black-Scholes	A mathematical model for pricing European call and put options, assuming constant volatility and no jumps in asset prices.
		CEV (Constant Elasticity of Variance)	An extension of the Black-Scholes model where volatility is a function of the underlying asset price, allowing for volatility to change with the asset price.
	Stochastic	Gram-Charlier Series	A series expansion used to approximate the probability distribution of asset prices, providing flexibility in capturing different distribution shapes.
		GARCH (Generalized Autoregressive Conditional Heteroskedasticity)	A model that describes the volatility of returns as a function of past returns and past volatility, useful for capturing time-varying volatility.
		Merton Jump Diffusion	An extension of the Black-Scholes model incorporating both continuous price changes and discrete jumps, allowing for sudden price movements.
		Jump Diffusion	Similar to Merton's model, this approach includes jumps in the asset price process alongside continuous changes, capturing abrupt price shifts.
		Heston Model	A stochastic volatility model where volatility follows its own random process, offering more flexibility in modelling asset price dynamics compared to the constant volatility assumption in Black-Scholes.
Non-Parametric		Kernel Regression	A non-parametric method for estimating the relationship between variables, used for smoothing data and estimating option prices without assuming a specific functional form.
		Neural Network	A computational model inspired by the human brain, capable of learning complex patterns and relationships from data, used for pricing options by modelling non-linear relationships.
		Yatchew-Boss Regression	A non-parametric regression technique that combines kernel smoothing with local polynomial fitting to estimate option prices without imposing strong parametric assumptions.

Source: Authors' contribution.

Studies on Pricing Efficiencies of Black-Scholes Framework in the Past: An Evidence from Some Country Specific Studies

Evidences from the literature that proves the Black Scholes being appropriate model to model option prices.

Black and Scholes (1973) proposed a theoretical formula for valuation of options which are based on specific characteristics in context of market factors. To list precisely, spot, volatility, time to maturity and expected risk-free rate of return which imply a risk neutral framework. Kim (1997) tested this BS model for "at the money options" and proved the efficiency of option pricing models. While McKenzie (2007) interestingly pointed out relative accuracy of BSM over others through his study of comparative qualitative regression models. Recently, on the similar lines, Sharma and Arora (2015) selected random 10 stocks of NSE and tried to study the relevance of BS framework in option pricing and supported relevance of BS framework to accurate pricing.

Black Scholes model heavily misprices in modelling option prices: Empirical evidence from literature.

Unlike the above contributions there were few seminal works which criticised the efficiency of Black Scholes model through their empirical examinations. Bates (1995) discussed empirical techniques and models for option valuation models. The study mainly focussed on testing the performance of time series techniques for valuation of options by ARCH /GARCH model. The results indicated more noise and divergence from time series properties of asset prices and implicit volatilities than initial ones.

To have more sustainable input parameters, model's parameters are computed analytically by optimization techniques in Coleman & Li (1996). They are further used as an input to find out the efficiency of the models against the benchmark Black Scholes model for pricing Nifty index option contract with market specified value. This paper has adopted a unique tool for evaluating the performance of option pricing models that involves calculating the error metrics. To judge how well a model performs, the study focuses on the relative error generated by the models.

Whereas Bakshi (1997) emphasized on the importance of stochastic volatility to improvise Black Scholes formula. With the advent of new innovative mathematical and statistical techniques with ages, efforts were being made to utilise those in real time option pricing.

Slowly and gradually, as the volume of trade for options started to gain momentum in India, researchers began to actively increase their efforts to study the Indian market. Singh (2013) forecasts the effectiveness based on the pricing accuracy of models. The study portrays the DVF and Heston's model as having more minor out-of-sample valuation errors in pricing NIFTY Index options than BSM, constant elasticity of variance, Gram-Charlier, and Hull and White models. However, none of these models eliminate price bias. This is mainly due to the unrealistic assumptions of the Black Scholes model: i) Assets follow a log-normal distribution, and ii) the underlying volume remains constant throughout the life of options. The deviations were studied using NIFTY Index options Bhav copy data, and the methodology of the out-of-sample forecasting performance of the models has been compared. This study encouraged us to verify whether the smaller out-of-sample valuation errors are model-specific and whether these errors depend on the data span. This study considered only two years of data to testify to the results.

One similar study concerning the French stock market came from Aboura (2013), who discussed various option valuation models based on empirical tests. This study tries to examine the methods that account for "non-normal skewness and kurtosis" and relax the martingale restriction imposed by the model by mixing two log-normal distributions, which are allowed either for the jump-diffusion process or for stochastic volatility. The findings suggest that the use of a jump-diffusion and stochastic volatility model performs well (fewer errors) and includes non-normal skewness and kurtosis in terms of precision in the option valuation.

In 2016, NSE became the world's second-largest derivatives trading exchange, based on the trading volume (according to the FIA report). This, in turn, pumped in the efforts of researchers to shift their focus specifically on case studies having evidence from the NSE derivatives market. Sethi and Nilkantan (2016) selected the most active ten stocks of NSE and tried to study the relevance of the BS framework in option pricing.

Kumar and Agarwal (2017) evaluate the efficiency of the BSM model using NSE data. This study empirically investigates the pricing accuracy of 2826 put option contracts written over the underlying equity index "Nifty50", calculated under the Black-Scholes option pricing model. Mispricing of deep-in-the-money and out-of-the-money call options using the BSM model is validated empirically on NSE data. Findings also suggest that the cost of carry concept was totally ignored while pricing futures were undervalued, resulting in a negative cost of carry problem. Hence, they observed that BSM would misprice the options due to negative carry cost, which further opens the scope for researchers to address this problem and overcome mispricing.

Kanojia and Jain (2017) compare the performance of BSM with GARCH models, and the results obtained are the same as previous findings that BSM models misprice and have huge errors owing to unrealistic assumptions and the fact that implied volatility is not considered.

Evidence of Differences in the Performance of the Black Scholes Model in Pre- and Post-Crisis Periods

Lately, there has been a lot of discussion over the efficiency of the Black Scholes Model during periods of upheavals in the market. To list a few of them, Angeli and Bonz (2010) evaluated the performance of the BS model for pricing stock options and found clear evidence of a massive difference in performance before and after the 2008 crisis.

Another one, in the Indian context after the subprime crisis, was of Singh (2013), which displays the ineffectiveness of the relative pricing accuracy of the BS model for pre-financial crisis period and post-financial crisis period of 2008 by considering the NIFTY index options for the period 2007-2008.

A few others who contributed to the same thought, Bates (2012), Fulop et al. (2014), Calvet et al. (2015), Driouchi et al. (2018), Luo et al. (2018), Kukolj et al. (2012) were proving the inefficiency. To the authors' surprise, they did not find any study that could support the efficiency of the Black Scholes model during the crisis period.

In conclusion, while the Black-Scholes model remains a foundational concept in option pricing, empirical studies and market observations have highlighted its shortcomings and the need for more robust and adaptable models in modern financial markets, especially during crises.

Some Explorations from Experiments on Deterministic Option Pricing Models

CEV Model (One-Factor Model)

Broadie and Detemple (2004) surveyed the literature on option pricing models based on the type of options valuation process, i.e., European and American. The study also discussed various applications of numerical methods and option pricing for more complex securities like exotic options or swaps, emphasizing recent trends and developments in methodology and modeling.

Another notable one was by Dias and Nunes (2008). It has shown that the identification and interpretation of the exact underlying processes are crucial, and a firm that sticks to the standard Black Scholes model is bound to have errors of analysis that may lead to non-optimal investment and disinvestment decisions. This hints at the significance of fair pricing models for investors in the market. Singh and Ahmad (2011) attempted to forecast the performance of the option pricing model on Nifty 50 index options by using the CEV pricing method. They compared it to performance of benchmark Black Scholes model for a period of 1 year. The results showed a significant difference in accuracy between the CEV model and BSM.

Hence, the discussed studies underscore the significance of fair and accurate pricing models like the CEV model in guiding investors toward informed and optimal decisions in the options market. Continued research and development in option pricing methodologies are essential for addressing market complexities and improving decision-making processes for market participants.

Some Explorations from Studies Using Time Series and Stochastic Models

GARCH Model

Straja (1994) also used the first few terms of the Gram Charlier series and proved that the performance of this series outperformed the Edgeworth series. Backus et al. (2004) examined the performance of Gram-Charlier expansions for option pricing, which suggested that the kurtosis in currency prices and biases in Black-Scholes option prices decline with maturity. This study reinforces the importance of fair pricing of assets overall and not derivatives. It also validates our initial thoughts that all categories of equity derivatives are better priced with some other model than BSM.

Prokopczuk (2009) analyzed American option valuation when underlying follows a GARCH volatility process. Chateau and Dufresne (2017) derived properties that lead to the definition of a process with independent Gram-Charlier increments, formulas for option pricing, and sensitivities.

Heston Model and Heston Nandi GARCH Model

Dunn et al. (2014) estimated the S & P 100 data from January 1991 to June 1997. The study compared the estimates obtained using the Method of Moments and Maximum Likelihood estimation.

Root means square error estimates obtained using both models were compared, and finally, the Heston model performed better than the benchmark Black Scholes model. This study was peculiar in considering it as one of the models to be tested for Nifty Index options as it has regarded a 3-month span from each of the seven years, and it obtained the supremacy of the Heston model over BSM.

Chang, Wang and Zhang established a new proposed double Heston model with approximate fractional stochastic volatility using the Radon-Nikedym derivative technique for option pricing. Ahy (2020) analyzed the model accuracy, which varied using more moments in the Gram-Charlier approximation of Heston option prices.

Jump Diffusion Model

Beckers (1981) suggested a novel method to estimate the parameters efficiently using the method of moments, which is different from its previous counterpart. Bates (1988) derived asset market equilibrium when asset prices follow the jump-diffusion process. They validated that an unknown but accurate option pricing model is obtained when jump risk is systematic and non-diversifiable with certain constraints imposed.

Bates (1995) surveyed extensive literature on stock options, options on stock indices, index futures, and currency options. Extracting the key inputs from this study, Craine et al. (1999) used a simulation-based estimator to predict continuous time stochastic volatility jump-diffusion process and showed that mis-specified models allow for jumps but not stochastic volatility. Kou (2002) introduced a double exponential jump-diffusion model. This assimilated the leptokurtic feature of the underlying distribution and the heavier tails than ordinary ones.

Clift and Forsyth (2007) showed that a fixed point exists whose iteration converges to typical market parameters and is verified through numerical tests. Liu and Wan (2018) put forth a hypothetical version of an improvised jump-diffusion model with a lognormal jump. They combined it with the Lee-Mykland method to identify jump and use the maximum likelihood estimation method to estimate parameters. The recognition of jump and estimate of parameters were accurate. With many of these studies contributing to a theoretical framework for jump-diffusion processes and lesser empirical testing evidence, we included empirical testing of Jump-diffusion models in the thesis.

These studies highlight the importance of using advanced parametric models like GARCH, Heston, and jump-diffusion models for more accurate options pricing, especially in capturing complex market dynamics and reducing biases compared to traditional models like Black-Scholes. Continued empirical testing and refinement of these models are essential for enhancing their effectiveness in financial markets.

Literature for Some Cross-Model Studies Amongst Parametric Models

Mills et al. (1992) carried out a large-scale comparison of various models of historical market data. They used numerical techniques using a connection machine to critically analyze the pricing structures of American options with their direct relation to bid-ask spread in the market.

Singh and Pachori (2013) investigated the out-of-sample forecasting performance of a model in a period of upheaval. The models analyzed included a combination of deterministic models like Practitioner Black Scholes models (PBS), Gram Charlier (GC), and Constant Elasticity of Variance (CEV) model. Efficiency is validated using error metrics. The method used for estimation of parameters is different from Whaley's method. Compared to other models, PBS has more minor out-of-sample valuation errors in pricing Nifty Index options. Singh (2013), again, in an extension of his earlier work, also added Hull and white model to the analysis but concluded that no model could substantially eliminate pricing bias.

Aboura (2013) studied the French option market and carried out a cross-model study to conclude that the jump-diffusion model could eliminate the price bias significantly relative to other models like benchmark Black Scholes, Gram Charlier, Longstaff model, a mixture of the lognormal model by Thomas and Melick, Hull and White model. The study puts forth a different perspective on estimating implied parameters, emphasizing skewness and kurtosis distributions.

Singh and Dixit (2016) compared the performance of Hesston's model and Black Scholes' for pricing equity index options. This model is a popular choice amongst academicians and practitioners. Although there was no study till this study came up, wherein the model's performance was studied using tick data one –day ahead of sample performance. The study found that Heston's model accurately prices the options, unlike the BS model, especially for low volatility and deep OTM options.

Authors' could observe one thing from the above efforts at cross-model studies that although there has been evidence that stochastic models are more robust and advantageous than deterministic models (mentioned in research gaps), researchers have a particular emphasis on deterministic models and have not attempted to explore the efficacy of the stochastic models in a model approach, especially in Indian context.

A Different Perspective Toward Option Pricing: "Non-Parametric Techniques"

The existing parametric models in literature revolve around their world of assumptions and constraints depending upon the assumption of the distribution function that the asset follows. A different approach evolved with the advent of technology, software, ML, and AI. This approach tried to free the models from this set of assumptions to enhance the flexibility of the model and its ease of interpretation as well. Below are some studies based on a few techniques that we reviewed to get insights into non-parametric techniques

The Kernel Regression Method

Henderson and Parmeter (2009) surveyed existing methods in the literature and discussed empirical implementation for sequential quadratic programming methods. They further simulated it, providing a brief distinguished analysis of constrained and unconstrained non-parametric techniques. Ouamaliche and Sayah (2020) used the Kernel-density estimation approach and applied it to the Asian option, and the results hence obtained were compared to the Monte-Carlo procedure. The results obtained were more accurate for test cases. Geng (2020) proposed a dynamically controlled Kernel estimation that outperforms the Least-squares Monte Carlo (LSM) approach, especially for predicting sensitivities and around the 'tails'.

Neural-Network Method

(Hutchinson, 1994; Lo & Poggio, 1994) used the technique of learning networks to price the options when underlying asset price dynamics are unknown for a two-year training dataset. A comparison of four methods is adopted: radial basis function, ordinary least squares, multilayer perceptron network, and projection pursuit. Mostafa and Dillon (2008) compared ANN performance with BSM and GARCH performance, where a crucial change was that ANN is trained on Implied volatility rather than the option price.

(Liu, 2018; Oosterlee & Bohte, 2018) recently used ANN to solve three types of solvers: the Black-Scholes equation, the COS method for the Heston stochastic volatility model, and Brent's iterative root finding method for IV calculation. It consumed less time for computational purposes. Ke and Yang (2019) studied the performance of deep learning models on option pricing using inputs to the famous Black Scholes model. It hints that future efforts using historical data should consider predicting bid/ask prices as "multi-task learning" performed better for bid/ask than equilibrium prices.

The Yatchew-Bos Regression Model

Yatchew (1998) introduced nonparametric procedures that are relatively simple. Ques draw upon many of these ideas. When identical objects are unavailable, the kernel estimation averages similarly distributed objects to estimate the collection of conditional means, known as the regression function.

Like the spline fitting technique, nonparametric least squares minimize the sum of squared residuals but find smoother functions and try to fit them. Tests on residuals provide a means of assessing a broad range of hypotheses, such as whether the sign of the slope of a relationship change or whether the relationship is additive, concave, or homothetic.

In summary, transitioning from traditional parametric models to more flexible non-parametric techniques represent a significant advancement in option pricing. The reviewed studies provide strong evidence of these methods' benefits, paving the way for more accurate and adaptable financial models.

Semi-Parametric Technique

Lo (1987) defined the upper bounds as dependent only on the mean and variance of the terminal stock price and not its entire distribution, hence termed semiparametric. Fan and Mancini (2009) used the state price distribution instead of the state price density because the former is more easily estimated. A particular nonparametric test is developed on the generalized likelihood ratio to capture the efficacy of the ACE method.

Wu et al. (2017) proposed a semi-parametric model based on the quadratic polynomial model Borokova (2006) suggested. A Gaussian function is used to smooth the quadratic term, and arbitrage-free constraints are used to calibrate the model. This model gave a better fit and forecast. While Li et al. (2020) developed a fractional option pricing model along the same lines as the state price density function. This study is based on 50ETF option data from the Shanghai Stock Exchange (SSE). With the advantages of this integrated approach over the pure parametric or pure nonparametric techniques, we also tried to incorporate a few semi-parametric methods in the analysis of pricing structures.

Thus, these studies underscore the evolving nature of option pricing methodologies and the potential of semi-parametric techniques in achieving superior model performance and practical applicability.

Literature for Cross-Model Studies Based Upon Both Parametric and Non-Parametric Models

Daglish (2003) examined how parametric and no parametric option pricing techniques could explain the Australian Stock Price Index. The uniqueness of this study lies in the choice of a dataset of American options and a unique spline-based technique of fitting for pricing. Findings suggest that for in-sample performance, parametric techniques outperform other models, but when considering the out-of-sample performance of the option pricing model and hedging, parametric models outperform the different models.

Hence, Deoda (2011) focused on performance using non-parametric techniques. The analysis examined CNX Nifty index call options for the period commencing from January 2008 until July 2010 with 21372 data points. Near-month options were considered for this study. Most of the option pricing studies till then were based on developed market data, especially in the US. The study states that the Multi-Task Learning model & hybrid models built using clustering techniques improved the pricing accuracy by over 50% compared to the Black-Scholes model. The results suggest that the non-parametric machine learning techniques outperform the BS model and are promising enough for the problem under consideration. His research contributed to developing new hybrid methods for option pricing, especially if we have American options for pricing. Findings supported hybrid SVR and kernel estimation models to outperform other techniques while efficiently pricing options.

Overall, these studies emphasize the evolving nature of option pricing models, with non-parametric and hybrid machine learning techniques showing great potential. They suggest that continued exploration of these advanced models could lead to more accurate and robust option pricing strategies, particularly in diverse market conditions and different options.

Research Gaps

Gaps in Existing Literature

Academic journals publishing post-pandemic research primarily cover a range of industries. However, there is a dearth of study on how the pandemic has affected financial markets, particularly those in emerging nations like India. Studies about option pricing models are extremely rare, especially when it comes to India. The flexibility given in the volatility function is the main reason why deterministic models are used in most established research. Dumas et al. (1998) noted that even on the Nifty 50 index, deterministic models do not always enhance the Black-Scholes model's performance when applied to future option pricing.

To evaluate option pricing efficiency in the Indian market, more research on non-parametric methods and stochastic volatility models is required. In a bibliometric analysis, Kulkarni and Pandit (2022b) emphasized how tiny data windows and limited breadth characterize global trends in option pricing models, especially non-parametric models. Since the establishment of derivative markets and an increase in global trade volumes after 2000, developed countries have dominated the majority of significant research on option pricing. However, since 2005, research has increasingly focused on model-specific studies using parametric and non-parametric models, especially during financial crises like the one that occurred in 2007–2008.

In comparison to theoretical research, there are not as many empirical tests of non-parametric models conducted. Addressing these gaps, integrating stochastic and deterministic models, and investigating non-parametric methods may help to create option pricing frameworks that are more reliable and accurate.

Research Gaps in Methodology

Many studies use the methodology from Bakshi et al. (1997) to solve inverse problems and obtain optimal parameters for pricing vanilla options. However, the initial parameter values used are often assumed or based on a trial-and-error approach, lacking systematic selection criteria. Limited empirical studies, particularly by Singh (2011), Singh (2013), Singh (2015), focus on cross-model performance in the Indian market, highlighting a need for comprehensive studies using stochastic models.

The National Stock Exchange of India (NSE) has become the largest derivatives trading exchange worldwide since 2019, yet research examining option pricing models in this market is insufficient. The Nifty 50 index options are among the top five global contracts traded in the equity category, emphasising the need for more profound research into model persistence and their practical applicability in Indian markets.

Addressing these gaps, as observed from the above model-specific literature and recent bibliometric studies, is crucial. Combining it with leveraging the strengths of deterministic and stochastic models and a few non-parametric techniques, future research can contribute to developing more accurate and robust option pricing frameworks. If we obtain any model that could persist over time, why can't we use such models for pricing options in the market?

Conclusion

The literature review is systematic and highlights significant deficiencies in the investigation of option pricing experiments, particularly in emerging markets like India. Although research has been conducted extensively in developed countries, there is a dearth of empirical work on non-parametric models and stochastic volatility frameworks in the Indian financial markets. Despite the inability to accurately represent market realities, deterministic models continue to be utilized and other methods that incorporate stochastic approaches are necessary.

Table 2: Summary of Key Theme, Research Gap, and Scope for Future Work

Key Theme	*Research Gap*	*Scope for Future Work*
Post-pandemic research focus	Lack of studies on the impact of the pandemic on financial markets in emerging economies like India	Encourage targeted studies on post-pandemic financial market behaviour, especially in Indian context
Option pricing models in India	Scarcity of research on option pricing in India; few studies on non-parametric and stochastic volatility models	Conduct empirical research using advanced models on Indian indices like Nifty 50
Use of deterministic models	Deterministic models, despite flexibility in volatility functions, fail to outperform under certain market conditions (e.g., Nifty 50)	Explore hybrid models that integrate deterministic and stochastic approaches for better realism
Non-parametric methods	Bibliometric studies reveal limited usage of non-parametric methods due to small data windows and narrow scope	Expand empirical studies using non-parametric techniques with larger datasets and broader scope
Global vs Indian research trends	Dominance of developed countries in research; emerging markets underrepresented post-2005 despite growing derivative trade	Shift focus to model-specific and region-specific research, especially during and after financial crises
Methodological limitations	Parameter selection often arbitrary; lack of systematic approaches in model calibration	Develop systematic, data-driven frameworks for parameter estimation and validation
Empirical testing	Insufficient empirical validation of non-parametric and stochastic models in Indian markets	Increase testing of advanced models under real-life scenarios with high-frequency market data
NSE's global position	Despite being the largest derivative exchange since 2019, limited studies on Indian option pricing models	Leverage NSE's position to undertake deep market analysis and test model persistence and robustness

Key Theme	*Research Gap*	*Scope for Future Work*
Hybrid model potential	Gap in leveraging combined strengths of stochastic, deterministic, and non-parametric models	Innovate hybrid frameworks for accurate, resilient option pricing across market regimes
Use of ML and data science	Traditional models dominate; underuse of machine learning and data-driven strategies	Integrate machine learning and big data analytics to improve forecasting and model adaptability
Model performance persistence	Lack of long-term validation of model performance across market cycles	Focus on developing and validating models that persist and adapt over time for practical use

Despite the potential for robustness of non-parametric techniques in dynamic market conditions, existing literature has largely relied on parametric methods and traditional option pricing models instead. In addition, the review highlights methodological gaps, such as the selection of initial parameter values and the validation of models using empirical evidence in real-life market scenarios. Despite the rapid expansion of derivative trading in developed economies, emerging markets remain unexplored due to their limited focus on option pricing research.

Bridging these gaps in future research would be more likely to use hybrid models using both deterministic and stochastic techniques, as this would allow for greater flexibility in market behaviour. Moreover, machine learning algorithms and data-driven approaches can be employed to improve the predictive accuracy of option pricing models. Considering the Indian National Stock Exchange's growing prominence in international derivative trading, there is a pressing necessity for effective pricing mechanisms that are aligned with market realities.

Finally, a model that can sustain performance and persist over time should be flexible for use in practical option pricing. The resolution of these research deficiencies can aid scholars and practitioners in developing more dependable, precise, and empirically proven option pricing models, ultimately improving the efficiency and stability of financial markets.

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