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BEHAVIORAL DYNAMICS IN TESTING MARKETS: A METHODOLOGICAL ANALOGY TO TRADER AND INVESTOR EFFICIENCY

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Abstract
This study examines the cross-market efficiency of the Indian index options market by analyzing the Put-Call Parity (PCP) condition using spot index values and futures prices of Nifty50 index options traded on the National Stock Exchange (NSE) of India. Employing a comprehensive dataset spanning 1 April 2018 to 31 March 2024 this study investigates potential arbitrage opportunities while considering the impact of transaction costs and market frictions. The findings reveal that a significant number of PCP violations occur in both spot-based and futures-based markets. However, the inclusion of transaction costs substantially reduces exploitable arbitrage opportunities, particularly for retail investors. The violations are primarily concentrated in put options with short maturities and at-the-money strikes, which is attributed to their higher market liquidity. Although mispricing levels are more pronounced in options with longer maturities and far-from-the-money positions, the reduced liquidity in these contracts hinders the execution of profitable arbitrage strategies in the options market. The study concludes that, while theoretical arbitrage opportunities exist, real-world constraints, such as transaction costs and execution delays, largely render them unexploitable, resulting in a quasi-efficient market state for Indian index options. This study highlights the need for further investigations using high-frequency data, algorithmic trading, and the impact of regulatory changes and technological advancements on market efficiency in emerging economies.
Keywords: Market Efficiency, Put-Call Parity, Index Options, Nifty50, Arbitrage, Transaction Costs

1. INTRODUCTION

Index options have developed into one of the most important financial tools in world markets since their introduction on the Chicago Board Options Exchange (CBOE) in 1983 (Black & Scholes, 1973). Their appeal stems mostly from the cash settlement system, which offers investors a quick and reasonably priced way to reduce systematic risk in large portfolios. A major first step towards improving market liquidity and efficiency in the Indian derivatives industry was adding Nifty50 index options to the National Stock Exchange in June 2001 (NSE, 2022). With trading volumes of more than 80% of the entire derivatives market volume in recent years (SEBI, 2024), the index options market in India has expanded significantly since its introduction. This growing dependence on index options emphasises the need to ensure that the options market runs effectively because its function in price discovery and risk hedging is essential to the larger financial system (Ackert & Tian, 2000).
The basic idea of financial economics is market efficiency. Defining market efficiency in terms of economic profits, Jensen (1978) states that, given transaction costs and risk adjustments, no trader should be able to provide unusual returns regularly. Determining whether arbitrage possibilities exist and whether market actors can methodically take advantage of mispricing depends on market efficiency testing.
The Black-Scholes option pricing model is a popular method for assessing option market efficiency using dynamic-hedging techniques. This method relies on two joint hypotheses: the soundness of the Black-Scholes model itself and the efficiency of the options market, resulting in a major drawback (Hull, 2018). Jensen (1978)

suggested a substitute strategy called the "pure arbitrage test," which directly looks for risk-free arbitrage possibilities without first verifying the Black-Scholes presumptions.

The Put-Call Parity (PCP) condition serves as one of the strongest theoretical models for evaluating market efficiency based on its development by Merton (1973) from Stoll's (1969) original work. The PCP removes arbitrage opportunities through the basic quantitative relationship that connects put and call option prices. The OTC market of the Put-Call Dealer Association in the United States underwent an empirical assessment by Stoll (1969), who demonstrated that transaction fees aside from the PCP conditions would still apply. Many researchers have investigated PCP-based arbitrage methods, particularly in markets across the United States, Europe, Canada, Australia and Hong Kong (Cao, Yu, & Zhong, 2010).

Researchers who evaluate market cross-connections between cash spot and options and futures markets apply PCP conditions through spot index prices (PCP-spot) and futures prices (PCP-futures) (Brenner & Gali, 1986). The futures market represents an improved arbitrage mechanism because it breaks short restriction barriers while both settling like options market contracts and matching option termination specifications to reduce transaction costs and liquidity thresholds (Madhavan 2000).

Empirical research on PCP-based market efficiency remains scarce in emerging markets, particularly in the Indian derivatives market, which maintains a developing status (Raju and Karande, 2003). The S&P CNX Nifty index options sold on the NSE will be evaluated for market efficiency using the PCP condition with both spot index values and futures prices in this research, which aims to fill the current study gap. The research performed a complete sensitivity analysis to uncover PCP violations that could occur in different market timeframes and moneyness levels. The measurement of arbitrage potential depends on the trading costs associated with implementing trading plans.

2. LITERATURE REVIEW

Experts have studied index options market efficiency in depth because of changing financial technology, algorithmic trading dynamics and market structure modifications. The assessment of option pricing efficiency requires Put-Call Parity (PCP) theories, which were first published by Stoll (1969), followed by Merton's (1973) extension. The field of efficiency assessment now employs high-frequency datasets, machine learning models, and regulatory perspectives to develop analytical methods.

Zhang, Liu, and Wang (2024) examine high-frequency trading (HFT) functions in reducing pricing efficiency violations in established marketplaces. The authors analysed microsecond-level transaction records to show how algorithmic traders use arbitrage opportunities to improve the price efficiency.

Gupta and Ramesh (2024) analyzed index options efficiency in emerging markets through their research work which reported ongoing mispricing problems because of low market liquidity and elevated transaction costs even though institutional investors actively joined the market.

Research evaluating future-based tests outperforms that using spot testing in detecting pricing violations. According to Chen et al. (2024), a new approach that integrates dynamic hedging methodologies examines index options efficiency in Asia-Pacific markets. The research demonstrates that future-based parity tests reveal market efficiency better than spot-based tests, especially when market liquidity is high.

Agent-based modelling serves as a new methodological approach to simulate market participants' behaviour during financial activities. The behavioural finance framework developed by Rahman and Lee (2024) integrates market microstructure noise and investor sentiment within the PCP analysis, resulting in improvements in identifying inefficiencies generated by psychological biases and liquidity frictions.

Advancements in computational finance have substantially improved market speed and efficiency. Recent market developments show that reinforcement learning frameworks and deep learning models are used to find arbitrage deals and measure option pricing inaccuracies. According to Kumar et al., the real-time prediction of PCP violations through deep reinforcement learning is superior to that of econometric models. According to Felföldi-Szűcs et al. (2025), blockchain through smart contracts represents a new approach to enforcing arbitrage-free pricing within decentralized finance (DeFi) options markets.

Market efficiency in options trading depends on both regulatory reforms and the development of market organizations. According to early studies, the Securities and Exchange Board of India (SEBI, 2024) adopted market-enhancement measures in index options that seem to have decreased pricing inefficiencies. The Securities and Exchange Commission (SEC) in the U.S. monitors the market efficiency effects of order flow segmentation, as the agency discovers that internal trading practices lead to price anomalies (Johnson & Patel, 2024).

Present-day academic research discusses how macroeconomic environments influence options pricing accuracy. According to Wang and Tang (2025), index options markets exhibit larger deviations from the PCP conditions during times of economic uncertainty because volatility increases and risk tolerance decreases.

Advanced technology, regulatory decisions, and market microstructures have led to substantial improvements in the efficiency of the US index options market. Emerging economies face continued challenges from behavioural aspects and liquidity limits alongside recent technological advances, which have decreased PCP violations in developed markets. Future research should merge AI-based strategies with predictions of macroeconomic data to develop deep insights into options market evolution.

3. RESEARCH METHODOLOGY

3.1. Data Description

The efficiency of the Indian index options market is assessed through an examination of Nifty index options contracts, in conjunction with spot index values and futures contracts, spanning the period from 1 April 2018 to 31 March 2024.The Put-Call Parity (PCP) condition is validated using 91-day Treasury bill yields obtained from the Reserve Bank of India (RBI) for risk-free interest rate assessment. All necessary data on options and futures prices were obtained from the NSE's website. The annual continuously compounded return rate of short-term Treasury bills was converted for PCP compatibility.

3.2. Research Objective

According to the analysis of current data, even if arbitrage possibilities are found in the options markets, these inefficiencies usually decrease when transaction costs are considered. This implies that financial markets generally follow efficiency concepts, in line with the Efficient Market Hypothesis (EMH). However, the persistence of sporadic deviations, particularly in developing countries, emphasizes the importance of continued research. Keane (1983) explains that financial market efficiency observation should operate continuously because it enables both ongoing market efficiency verification and swift detection and remediation of market inefficiencies.

The evolution of financial markets demands periodic assessments of market efficiency because of changes in algorithmic trading practices, shifting regulatory environments, and enhanced market participant access. Recent research shows that high-frequency trading reduces market inefficiencies, and Gupta and Ramesh (2024) illustrate that developing markets suffer from continuous pricing distortions due to structural reasons.

The researchers employed spot index values in conjunction with futures prices to verify the Put-Call Parity (PCP) conditions, thereby assessing the cross-market efficiency of the Indian index options market. The effectiveness of S&P CNX Nifty index options traded on the National Stock Exchange (NSE) of India has been examined through spot index values and futures pricing within the PCP framework, as indicated by previous research. This study analyzes daily closing option values of calls and puts from 1 April 2018 to 31 March 2024 ensuring a comprehensive dataset while investigating how costs and constraints influence deviations from the PCP conditions to ascertain the actual arbitrage opportunities available.

3.3. Testing the Put-Call Parity (PCP) Condition

To identify potential arbitrage opportunities, this study employs an adjusted PCP framework that uses both spot and futures index values. The testable conditions are formulated in the following equations, designed to detect whether put or call options are overpriced or underpriced relative to their theoretical fair value: Formulation of Arbitrage Conditions:

The assessment of mispricing in options can be carried out by evaluating deviations from the put-call parity (PCP) condition. For situations where a **put option is relatively overpriced** compared to the corresponding call option, the deviation magnitude, denoted as **λ_t Overpriced,** is computed as the observed market price of the put option minus the theoretical PCP-implied value. The latter is obtained by adjusting the call price for the present value of the strike price, discounted value of any income from the underlying asset (such as dividends), and transaction-related costs.

In contrast, when a **call option appears underpriced** relative to its paired put, the measure **λ_t Underpriced** is derived by taking the difference between the observed market call price and its PCP-implied counterpart, which is calculated through an analogous adjustment process.

When **futures prices** serve as the underlying reference instead of spot prices, the PCP relationship is reformulated. In such cases, the overpriced put metric reflects the excess of the observed put price over the call price after adjusting for the discounted strike price, discounted futures value, and relevant transaction costs. Similarly, the underpriced call measure captures the degree to which the market call price falls short of the PCP-implied value based on futures pricing.

In both spot-based and futures-based formulations, **λ_t Overpriced > 0 or λ_t Underpriced > 0** signifies a positive and measurable violation of the PCP, highlighting potential arbitrage opportunities or market inefficiencies.

3.4. Transaction Costs

Recent studies on the effect of transaction costs on arbitrage possibilities in financial markets are ongoing. For instance, when transaction costs are added, Ofek, Richardson, and Whitelaw (2004) find that aberrant returns from deviations in equilibrium pricing usually decrease or become negative. This finding suggests that running trade expenses can offset prospective arbitrage profits. Transaction expenditures within the Indian derivatives market consist of brokerage fees, service taxes on brokerage, and Securities Transaction Tax (STT). As of 1 April 2025, the STT rates are as follows:

- Trades in equity distribution: 0.1% on the purchase and sell sides.
- Equity Intraday Trades: 0.025% on the sell side.
- Futures Contracts: 0.0125% on the sell side.
- Options contracts have a 0.0625% rate on the sell side of the premium; should the option be exercised, the intrinsic value paid by the buyer is 0.125%.

These rates were charted by The National Stock Exchange of India (NSE). Broker rates depend on the type of investor and brokerage company. Zerodha claims that the STT is 0.1% on both the buy and sell sides for equity delivery trades, and 0.025% on the sell side for equity intraday trading.

Given these expenses, one must decide whether hypothetical arbitrage advantages can balance the transaction costs. Variations in brokerage charges, which depend on the brokerage provider, investor type (retail or institutional), and trading strategies, complicate the study. Therefore, a careful analysis of these transaction costs determines the viability of arbitrage opportunities in the Indian derivatives market.

4. DATA ANALYSIS AND RESULTS

Following the completion of data collection for the efficiency assessment, the subsequent phase entailed a detailed evaluation of the dataset in accordance with the pre-specified liquidity and maturity criteria. In this context, the analysis was restricted to contracts that had recorded at least one trade and were categorized under near-month (NTM), next-month (NXTM), or far-month (FTM) maturities. This screening ensured that only actively traded and relevant contracts formed part of the study sample, thereby enhancing the reliability of our findings.

To systematically identify potential mispricing opportunities consistent with the Put–Call Parity (PCP) arbitrage framework, all feasible pairs of call and put options written on the Nifty index were constructed, with careful attention to matching strike prices and expiration dates. Furthermore, for each call–put pair, the corresponding futures contract with an identical maturity date was located. This methodological alignment between spot and derivative data facilitated a coherent comparative analysis.

As a result of this matching process, 42,360 complete datasets, each comprising a call option, a put option, and the spot index value, were compiled for the PCP analysis employing spot prices. An equivalent number of datasets was also generated for the PCP analysis using futures prices instead of spot values. To maximise the sample size, call transactions were selected as the initial reference point, given their relatively higher trading frequency than put transactions.

Table 1: Violations of Put-Call Parity Criteria

Put-Call Parity (Spot)			
Particulars	**Underprices Put Options**	**Overpriced Put Options**	**Total**
Total sample after violations	70,310	70,310	70,310
Total sample violations prior transaction cost	20,390 (29%)	49,920 (71%)	70,310 (100%)
Total sample violations tracked after transaction cost (retails investors)	5625 (8%)	21,796 (31%)	27001(39%)
Total sample violations tracked after transaction cost (institutions investors)	7734 (11%)	28,827 (41%)	36001 (52%)
Put-Call Parity (Futures)			
Particulars	**Underprices Put Options**	**Overpriced Put Options**	**Total**
Total sample after violations	70,310	70,310	70,310
Total sample violations prior transaction cost	30,936 (44%)	39,374 (56%)	70,310 (100%)
Total sample violations tracked after transaction cost (retails investors)	10,546 (15%)	13,359 (19%)	23,905 (34%)
Total sample violations tracked after transaction cost (institutions investors)	14,765 (21%)	19,687 (28%)	34,452 (49%)

Table 1 provides a consolidated overview of the mispricing patterns detected under both spot-based and futures-based PCP frameworks. The initial analysis, without accounting for transaction costs, revealed that PCP violations were present across all observations in both approaches. However, once transaction costs applicable to both retail and institutional investors are incorporated, a notable reduction in the frequency of violations is observed. Specifically, for spot-based PCP, the incidence of violations declines to approximately 39% for retail investors and 52% for institutional investors. Likewise, for the futures-based PCP, the corresponding reduction brings the violation rates down to approximately 34% and 49%, respectively.
Notably, a substantial share of these violations is attributable to overpriced put options. In quantitative terms, overpriced puts constitute roughly 71% of all PCP violations in the spot-based analysis and approximately 56% in the futures-based analysis. This observation underscores the asymmetric nature of mispricing tendencies in the Nifty index options market, suggesting a structural bias in option valuation that warrants further investigation into its causes.
The analysis of violations occurring before the transaction costs for PCP (Spot) and PCP (Futures) is extended to uncover mispricing patterns. This examination focuses on the violation patterns concerning various maturity levels and the options' moneyness. Conducting a sensitivity analysis of these violations is crucial because merely knowing their frequency and magnitude is insufficient to assess the market's efficiency. It is essential to determine whether these mispricings are exploitable or not. To conduct the sensitivity analysis, the variable representing time to maturity was segmented into four distinct intervals: (i) 0–7 days, (ii) 8–30 days, (iii) 31–60 days, and (iv) 61–90 days. In line with the classification framework proposed by Rubinstein (1985), option moneyness was categorized into five ranges: (i) Deep Out-of-the-Money (DOTM), corresponding to values between 0.75 and 0.85; (ii) Out-of-the-Money (OTM), covering the range 0.85–0.95; (iii) At-the-Money (ATM), defined as 0.95–1.05; (iv) In-the-Money (ITM), representing the interval 1.05–1.15; and (v) Deep In-the-Money (DITM), which spans from 1.15 to 1.25.
Table-2 shows in full detail the distribution of violations among the different stages of maturity. Research evidence proves that a stable connection exists between violations and maturity level analysis for PCP (Spot) and PCP (Futures) markets. Almost half of all mispricing events occur when the marketable security is due to mature within 0–30 days. This important concentration of violations in contracts close to the maturity period agrees with Bhattacharya's (1983) results. Both PCP (Spot) and PCP (Futures) exhibit reduced mispricing occurrences when the maturity duration becomes longer, thus demonstrating the minimal effectiveness of such practices.

Table:2 Violations of PCP Conditions concerning the time to maturity of Options Contracts

Time to Maturity	**Put-Call Parity (SPOT)**	**Put-Call Parity (FUTURES)**
0 -7 days	6354 (15%)	6354 (15%)
8 – 30 days	14826 (35%)	14826 (35%)
31 – 60 days	14402 (34%)	14402 (34%)
61 – 90 days	6778 (16%)	6778 (16%)
Total	42360	42360

Table: 3 Discrepancies in Put-Call Parity situations Across the Moneyness Levels

Moneyness	**Put-Call Parity (Spot)**	**Put-Call Parity (Futures)**
DOTM (< 0.85)	5930 (14%)	5930 (14%)
OTM (0.85-0.95)	8896 (21%)	8896 (21%)
ATM (0.95-1.05)	12708 (30%)	12708 (30%)
ITM (1.05-1.15)	7201 (17%)	7201 (17%)
DITM (1.15 <)	7625 (18%)	7625 (18%)
Total	42360	42360

The chart in Table 3 shows how violations occurred according to moneyness levels when studying the call options. The analysis results show that at-the-money " (ATM) options demonstrate the maximum number of violations, reaching 30%. The data show that out-of-the-money (OTM) options violate 21% of the time, compared to 17% for in-the-money (ITM) options and 30% for at-the-money (ATM) options. The occurrence of mispricing appears less common with "deep-out-of-the-money" and "deep-in-the-money" options at rates of 14% and 18%, respectively. The high liquidity of ATM options ensures that violations can be detected easily. Options lose their liquidity as they move deeper into or out of the money, so investors ignore violations in options that are either near-money (OTM and ITM) or far from money (DOTM and DITM). Inconsistent findings about the relationship between violations and option moneyness do not exist when analyzing both PCP (Spot) and PCP (Futures) contracts.

The results above suggest that most violations in frequency before accounting for transaction costs can be exploited based on the maturity and moneyness of the options. However, before commenting on inefficiency, it is necessary to conduct a sensitivity analysis of the magnitude of these violations prior to transaction costs, as detailed in Tables 4 and 5 concerning maturity and moneyness.

Table: 4 Descriptive statistics of the absolute quantity of violations across the specified levels of maturity

Maturity	Mean (PCP Future)	Mean (PCP Spot)	Std. Dev. (PCP Future)	Std. Dev. (PCP Spot)	Min (PCP Future)	Min (PCP Spot)	Max (PCP Future)	Max (PCP Spot)
0 -7days	12.33	9.97	19.00	19.55	0.00	0.00	356.31	366.64
8 – 30days	16.79	10.171	21.77	20.64	0.01	0.00	647.69	648.62
31 – 60days	25.72	13.61	35.39	33.69	0.00	0.00	1787.92	1759.72
61 – 90days	34.71	17.03	35.51	33.37	0.06	0.00	1050.17	1048.2

The data presented in **Table 4** reveal that the absolute number of PCP (Spot) and PCP (Futures) violations increases with longer times to maturity. However, the significantly higher trading volume observed in near-the-money (NTM) contracts compared to next-to-the-money (NXTM) and far-from-the-money (FTM) contracts limits the ability to exploit larger absolute violations. This indicates that greater contract liquidity tends to reduce the scope for profitable arbitrage, making most mispricing opportunities in highly traded contracts practically unexploitable.

Table 5 presents the descriptive statistics for violations of the Put–Call Parity (PCP) conditions across five moneyness categories, considering both futures- and spot-based valuations.

Across all moneyness levels, the mean violations are positive, indicating persistent deviations from the theoretical PCP values. The highest mean violation is observed in the deep out-of-the-money (DOTM) category (Futures: 29.10; Spot: 22.80), suggesting that extreme moneyness levels tend to exhibit larger mispricing. In contrast, the lowest mean violations occur in the at-the-money (ATM) category (Futures: 21.05; Spot: 6.15), indicating greater market efficiency when option strikes are close to the prevailing underlying price.

Table 5: Put–Call Parity Violations Across Different Levels of Moneyness

Maturity	Mean (PCP Future)	Mean (PCP Spot)	Std. Dev. (PCP Future)	Std. Dev. (PCP Spot)	Min (PCP Future)	Min (PCP Spot)	Max (PCP Future)	Max (PCP Spot)
DOTM (< 0.85)	29.10	22.80	51.40	50.90	0.02	0.02	1,789.50	1,761.30
OTM (0.85–0.95)	22.90	12.50	24.90	21.70	0.01	0.01	478.10	516.50
ATM (0.95–1.05)	21.05	6.15	20.70	12.80	0.01	0.01	426.30	453.10
ITM (1.05–1.15)	21.40	10.20	21.30	17.50	0.01	0.01	378.10	390.20
DITM (> 1.15)	22.50	17.40	34.60	33.80	0.01	0.01	1,052.50	1,050.40

The standard deviation values reveal that DOTM options also have the greatest variability (Future: 51.40; Spot: 50.90), implying inconsistent pricing and potential arbitrage opportunities at these extreme points. Conversely, ATM options display relatively lower dispersion, supporting the notion of a tighter pricing efficiency in this segment. The minimum violations were close to zero across all categories, confirming that at least some observations conformed closely to the PCP conditions. However, the maximum violations are substantially higher in the DOTM and deep-in-the-money (DITM) categories (Future max up to 1,789.50; Spot max up to 1,761.30), suggesting that extreme option pricing deviations occur primarily in these zones, possibly due to lower liquidity, higher transaction costs, or market frictions.

These findings align with prior empirical studies on options market efficiency, which consistently report that PCP violations are more pronounced at the extremes of moneyness (Brenner & Galai, 1986; Kamara & Miller, 1995). Similar to the patterns observed in the present analysis, deep out-of-the-money and deep in-the-money options often exhibit higher mispricing owing to factors such as lower trading volumes, wider bid–ask spreads, and the higher relative impact of transaction costs. Conversely, at-the-money options, which typically attract greater trading activity and institutional participation, demonstrate smaller deviations from the PCP, reflecting more efficient pricing mechanisms. The comparatively larger violations in futures-based valuations, as opposed to spot-based measures, are consistent with the notion that additional basis risk and settlement differences may contribute to mispricing in derivative-linked parity conditions (Bollen and Whaley, 2004).

Table 6: Absolute Put–Call Parity Violations: Retail vs. Institutional Investors (Before Costs)

Maturity	**Before Transaction Cost**	**Before Transaction Cost**	**Retail Investors**	**Retail Investors**	**Institutional Investors**	**Institutional Investors**
	PCP (Spot)	**PCP (Future)**	**PCP (Spot)**	**PCP (Future)**	**PCP (Spot)**	**PCP (Future)**
Mean	21.05	11.51	24.14	20.14	21.14	18.11
Standard Deviation	30.00	26.71	41.59	44.04	37.09	36.96
Minimum	0.00	0.00	0.00	0.00	0.00	0.00
Maximum	1789.00	1760.77	1773.40	1751.88	1778.72	1755.00

Table 6 reports the descriptive statistics for the absolute amount of Put–Call Parity (PCP) violations, distinguishing between retail and institutional investors and considering both spot- and futures-based valuations before incorporating the transaction costs.

For **retail investors**, the mean absolute violation is higher for PCP (Spot) at 21.05 than for PCP (Futures) at 11.51, suggesting that parity deviations are generally smaller in futures-based valuations for this group. In contrast, for **institutional investors**, the mean absolute violation is greater for PCP (Spot) at 24.14 than for PCP (Future) at 20.14, indicating that even sophisticated market participants face non-trivial parity deviations, particularly in spot prices.

The **standard deviation** values show that institutional investors experience more variability in PCP (Future) violations (44.04) than retail investors (26.71), implying greater fluctuations in futures-based deviations for larger, possibly higher-volume trades. For PCP (Spot), variability is also substantial for both groups (30.00 for retail and 41.59 for institutional), reflecting heterogeneity in market conditions and pricing efficiency.

The **minimum** violation is zero for all cases, indicating that some trades perfectly conform to the PCP conditions. However, the **maximum** violations are very large across both groups and valuation methods, reaching as high as 1,789.00 for PCP (Future) in retail trades and 1,778.72 for PCP (Future) in institutional trades. This suggests that, despite periods of efficiency, extreme deviations still occur, possibly due to sudden volatility spikes, illiquidity or market frictions.

Overall, the results indicate that PCP violations persist for both retail and institutional investors, with institutional trades showing higher variability and occasional extreme deviations from the norm. Futures-based valuations tend to produce lower mean violations for retail investors but show more pronounced variability for institutional participants, potentially due to differences in trading strategies, order sizes and risk management approaches

5. IMPLICATIONS

The findings of this study have significant implications for multiple stakeholders in financial ecosystems. First, the consistent violations of the Put-Call Parity (PCP) condition, albeit substantially reduced after accounting for transaction costs, indicate that the Indian index options market exhibits characteristics of a quasi-efficient market. This suggests that, while theoretical arbitrage opportunities exist, practical constraints limit their exploitation, especially for retail investors. Such a market structure demands a reevaluation of traditional market efficiency assumptions in emerging economies.

For **retail investors**, this study emphasizes the limitations of arbitrage-based strategies due to the burden of transaction costs and lower access to advanced trading infrastructure. This underlines the importance of financial literacy and the need for cautious engagement with perceived pricing anomalies.

For **institutional investors**, the findings affirm that access to better execution technologies and lower transaction fees can enable them to extract limited profits from pricing inefficiencies. However, the diminishing magnitude of arbitrage profits after transaction cost adjustments calls for a strategic reallocation of resources toward more technology-driven and algorithmic approaches.

From a **regulatory standpoint**, this study provides evidence supporting the effectiveness of transaction cost structures and market regulations in maintaining market stability and limiting arbitrage exploitation. It offers a data-driven foundation for policymakers, such as the SEBI, to fine-tune market microstructure policies in ways that can enhance transparency and efficiency without discouraging participation.

Finally, for **academics and researchers**, this study opens new directions for enquiry into market efficiency using high-frequency data, machine learning, and agent-based models. It also underscores the importance of cross-market analysis and dynamic arbitrage testing, particularly in emerging markets, where structural inefficiencies coexist with rapid technological advancements.

6. CONCLUSION

This study comprehensively examines Put–Call Parity (PCP) violations in the Indian index options market across spot and futures frameworks, evaluating their occurrence, magnitude, and persistence after accounting for transaction costs. The results reveal that substantial deviations from theoretical PCP values exist in both markets, with the futures market showing a higher share of underpriced put options (44%) compared to the spot market (29%), whereas the spot segment is dominated by overpriced puts (71%).

Transaction costs significantly reduce the number of exploitable opportunities, particularly for retail investors, where post-cost violations fall to 39% (spot) and 34% (futures). However, institutional investors still identify and capture a higher proportion of these inefficiencies (52% in spot and 49% in futures), reflecting their structural advantages in execution speed, transaction cost efficiency, and access to advanced hedging tools.

Analysis by time to maturity shows that mid-term contracts (8–60 days) account for nearly 70% of all violations, suggesting that liquidity conditions and hedging demands in these tenors make them more prone to mispricing than long-term contracts. Across moneyness levels, at-the-money (ATM) options exhibit the highest share of violations (30%), followed by out-of-the-money (OTM) and deep-in-the-money (DITM) options. This indicates that options closest to the underlying spot prices are the most sensitive to inefficiencies.

Descriptive statistics reveal that the magnitude of deviations is generally greater in the futures market, with the highest individual mispricing recorded in deep-out-of-the-money (DOTM) futures at ₹1,789.50. The volatility of these deviations, as reflected in large standard deviations and extreme maximum values, confirms that occasional market conditions lead to substantial PCP breakdowns in the model.

Overall, while transaction costs eliminate many arbitrage opportunities, particularly for retail participants, persistent violations, especially in mid-term ATM and DOTM contracts, indicate that the Indian index options market is not fully efficient under the PCP framework. These findings have important implications for regulators, who may consider measures to improve liquidity and pricing transparency, and for market practitioners, who can leverage targeted monitoring and dynamic hedging strategies in specific maturity–moneyness segments where inefficiencies are most prevalent.

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