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Innovative Digital Technologies and Their Impact on Traditional Financial Derivatives

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ABSTRACT:
Based on CME group (2025), The Chicago Board of Trade, USA was founded in 1848 and issued Standard Currency Future Contract after 17 years. The institution, which was originally a grain exchange, was later recognized as a symbol of the birth of the modern financial derivatives market. In a following century, the traditional derivatives like futures, swaps witnessed and accelerated the rapid development of this world and the liquidity, depth of the market. Wheras, in a recent decade, the proposal of new technological products, such as blockchain and Artificial Intelligence (AI) concepts, not only enhances information technology security, opens up the world of cryptocurrencies, and accelerates the speed of data analysis, but also provides a key opportunity for the traditional derivatives industry to embrace innovative development. This is one of the hottest topics in the financial world today: fintech and financial innovation. Hence, this essay is going to analysis how can these technologies can use or combine with derivative markets, and uncover the relevent risks and their corresponding risks.

KEYWORDS: Traditional Financial Derivatives

INTRODUCTION

Based on CME group (2025), The Chicago Board of Trade, USA was founded in 1848 and issued Standard Currency Future Contract after 17 years. The institution, which was originally a grain exchange, was later recognized as a symbol of the birth of the modern financial derivatives market. In a following century, the traditional derivatives like futures, swaps witnessed and accelerated the rapid development of this world and the liquidity, depth of the market. Wheras, in a recent decade, the proposal of new technological products, such as blockchain and Artificial Intelligence (AI) concepts, not only enhances information technology security, opens up the world of cryptocurrencies, and accelerates the speed of data analysis, but also provides a key opportunity for the traditional derivatives industry to embrace innovative development. This is one of the hottest topics in the financial world today: fintech and financial innovation. Hence, this essay is going to analysis how can these technologies can use or combine with derivative markets, and uncover the relevent risks and their corresponding risks

BLOCKCHAIN AND FINANCIAL DERIVATIVES

Blockchain is an emerging distributed ledger technology. It connects data in the form of "blocks" in chronological order through cryptographic methods and consensus mechanisms to form a chain structure.

Each block contains several transactions or records and is interrelated with the previous block, forming an unalterable chain. Punia, Gulia, etc. (2024) proved the decentralization, transparency and immutability of blockchain which enhance the security of the permission management system via researching and discussing the accessing control method. On the other hand, the financial industry relied on centralized institutions such as banks, clearing houses and payment platforms to ensure the security and credibility of transactions for a long time. As time goes on, such an outmoded mechanism appears the problems like high cost, low efficiency, and difficulties in cross-border payment. However, the zdecentralized concept provided by blockchain technology precisely offers an excellent decentralized, transparent and efficient solution for the financial industry and the derivatives that this article focuses on discussing. Shah, Lathiya, etc. (2023) proved that the decentralized financial market is experiencing exponential growth and has great potential. It can increase everyone's access to financial services through cutting down the demand for intermediaries.

Take the further consideration to the derivative markets, the blockchain technology can drive underlying logic of derivative services changes. During the step of contract design, blockchain can program contract terms (cash flow formulas, trigger conditions, interest calculation, redemption upon maturity, etc.) to automatically execute them based on conditions, reducing manual intervention. This is known as 'smart contract', which enables the term codes in the derivatives trading process to be read and audited, and makes all transaction timestamps transparent. Oluwajebe, Duah, Golnikova (2021) issued an example of interest rate swap, proved the fact that smart contract ensures the intelligence from end to end, succssefully maintained anonymity and enhanced market efficiency and security. In the step of matchmaking trading, the blockchain make the transaction is visible to every parties by the order book that belongs to Layer 1 or Layer 2, or the Automated Market Maker (AMM), RFQ smart contract to offer a price. Meanwhile, the transaction process can be replayed. As for the process of settlement and clearing, smart contracts can achieve atomic Delivery versus Payment (DvP), Payment versus Payment (PVP) and net settlement, which makes the settlement rules public and the settlement results can be audited. In the margin and risk control section, margin accounts on the blockchain can confirm leverage rates and margin rates in real time, enabling automatic margin call and liquidation. This leaves traces of positions and margins on the blockchain and hence makes the rules transparent. Perpetual Protocol (2024) provided the official terms set by Decentralized perpetual contract, it provides detailed liquidation trigger conditions and proveed that the margin will be automatically liquidated when it falls below the threshold. If the traditional custody steps are involved, the blockchain will automatically custody the accounts on the chain, which further ensures that the balance of funds and assets on the blockchain is transparent. When collecting the trading data, the multi-source oracle technology provided by blockchain utilizes Time-Weighted Average Price (TWAP) and median aggregation, take the threshold signatures as the standard, thereby making data sources and price-feeding paths transparent and monitorable. Under the process of rules checking, Blockchain will selectively discloses the license register, address whitelist, and quota control terms, enabling read-only nodes to obtain evidence in real time. As a result, by the help of decentralization concept and the automatic execution of the technologies mentioned above by blockchain, make the most of traing data are transparent and able to be verified.

The cooperation between blockchain and derivative markets is not just a theoritical guess, the cryptocurrency supported by blockchain technologies have interated with derivative markets for a long time. Amberdata (2023) issued that derbit traded the first batch of Bitcoin-based options as early as the Novemeber of 2016. Besides, CME group (2017) mentioned that CME also launched Bitcoin futures on December 18, 2017. This is the world's first large-scale regulated exchange to introduce crypto asset derivatives which not only marks that institutional investors have for the first time a large-scale compliant crypto risk hedging tool and venue, but also indicates that crypto derivatives have become a new trend in the financial sector. Lipsky (2024) also illustrated that JP morgan is trying to clear after swap transactions on the blockchain via the blockchain clearing platform: Onyx. This means the efficiency and transparency of the derivative markets is going to further improve, which also speeded up the development of 'smart derivatives contract'.

In addition to traditional financial institutions are attempting to integrate blockchain with the derivatives industry, Nasdaq Newsroom (2025) mentioned the exchange like Nasdaq also begin to try to tokenised the stocks and Exchange-Traded Fund on its market, and hence simplifying the trading process of stock index futures and options, which means that more efficient real-time clearing is possible. Moreover, Rathnam (2016) noted the post-transaction processing platform on blockchain issued by DTCC is used to test the blockchain-based processing capabilities of credit derivatives, it will reduce the operational risks of similar transactions.

Beyond that, blockchain technology itself offers unlimited possibilities for the derivatives industry, dYdX is a current famous decentralized derivatives exchange platform on blockchain. Tomar (2025) pointed out that users do not need to transfer their assets to a centralized custodian for custody. Instead, they can manage their funds and execute transactions through smart contracts in dYdX. Subsquently, the blockchain technologies used by dYdX is also keep updating, this marks that while its performance, throughput and decentralization capabilities are constantly improving, the cost is further shrinking. The main products on dYdX is perpetual contract, which is similar to a futures contract but has no expiration date. Thus, users can hold leveraged positions for a long time. Leveraged trading is another one, this platform enables users to open larger positions with smaller funds. Such a mature decentralized trading platforms marks a high degree of completion in the integration of blockchain technology and the derivatives markets, indicating that users can always have full control over the funds on their platforms and reduce the risk of centralized clearing houses going bankrupt. The transparent settlement rules and capital flows executed by code, as well as outstanding global accessibility, meaning the aforementioned advantages brought from blockchain technology have nearly become a reality.

AI AND DERIVATIVE MARKETS

The concept of AI is mentioned in the 50s of last century. Based on Krizhevsky, Sutskever and Hinton (2012), in the ImageNet image recognition competition in 2012, the Deep Convolutional Neural Networks have made numerous breakthroughs, which represents the AI has entered the era of deep learning. After the huge success get by Integrated AI platform ChatGPT in 2023, its powerful performance marks the future development direction of mankind. Experts in almost all industries are attempting to collaborate with AI, which includes the derivative markets as well.

One of the greatest difficulty suffered by derivatives is pricing. Derivatives can be frequently adjusted according to clients' needs, which is an advantage of derivatives. However, it also poses significant challenges for industry practitioners, as it greatly increases the complexity of derivative products, characterized by nonlinearity and multi-layered structures. The complex benefit functions, paths brought from exotic options, structured derivatives make it is almost impossible to analysis traditionally. As a result, AI can train pricing functions that approximate the theoretical value of complex derivatives via neural networks, such as deep convolutional neural networks (CNNs) or LSTMs, thereby reducing the computational cost of Monte Carlo simulations. People can also keep training AI so that optimize the exercise strategy, which is possible to find near-optimal early exercise points among path-dependent derivatives.

Homologous, derivative pricing also has the problem of highly unstable variables, as known as, volatility smiles, correlation failure, and difficulty in long-term prediction of macro variables. Peña, Rubio and Serna (1999) illustrated that the unstable volatility of different strike prices and terms can cause the pricing model to be skewed, making the traditional black-Scholes model ineffective and forcing practitioners to use more complex models for pricing. To solve this problem, AI can capture nonlinear changes via machine learning model like LSTM and Transformer to predict volatility surface dynamically, letting itself more flxible. Besides, AI can also model credit risks by integrating unstructured data such as financial reports, news, and social media, predict the probability of a company's default, and thereby price credit derivatives more accurately. Duan and Yao (2022) collected the news of North American company of last 20 years, after extracting media sentiment indicators, it was found that they could significantly improve the accuracy of default prediction, which supported the feasibility of the AI approach. Moreover, Graph Neural Networks (GNNs) can also be used to dynamically model the complex correlations among assets, and hence enhancing the pricing accuracy of multi-asset derivatives such as basket options and Collateralized Debt Obligations (CDOs).

The excessive idealization of factors in classic pricing model is another reason. In fact, there are many parameters that are difficult to calibrate simultaneously, and it is also hard to cover the risks of 'black swan' events in reality. In this case, AI does not rely on fixed assumptions such as a normal distribution or constant volatility, it can directly learn the relationship between price and risk. AI can also utilize machine learning algorithms to quickly infer implicit parameters (such as implicit volatility surfaces and risk-neutral distributions) from market data, thereby enhancing calibration efficiency and accuracy. As for those 'black swan' events, AI is capable to identify abnormal market data or potential extreme events in real time before human realised, thereby adjusting pricing or risk management models promptly.

Moreover, in the OTC derivative markets, the prices are dispersive, while the trading data are non-transparent with poor liquidity making it hard to predict the changes in prices. In response to this, AI can infer prices from similar assets through transfer learning and few-shot learning techniques. Not only that, the machine learning models of AI can predict the depth and liquidity of the market, therefore helping it to make more reasonable valuations in non-transparent markets. In addition, AI is able to analyze news automatically, regulatory documents, research reports, and alleviate information asymmetry, finally improve the comprehensiveness of pricing bases.

Apart from the difficuly in pricing, Paddrik and Tompaidis (2024) mentioned when the network of participants is sparse, the market is small or transactions are infrequent, the derivatives market will face the risk of large bid-ask spreads and insufficient liquidity. To solve this, AI can utilize AI-driven market-making techniques to dynamically adjust quotations, thereby narrowing bid-ask spreads. Besides, AI is also capable to predict the order flow and market shocks in advance, therefore helping to distribute and execute large orders and ensuring a smooth market transition. Cotter and Longin (2011) believed that the margin in the futures market is usually estimated based on the daily closing price, while the high-frequency fluctuations of the day are ignored. Such fluctuations can cause the margin pricing at the closing price to lag significantly when the market experiences severe volatility. This may result in liquidation and margin requirements failing to reflect risks in a timely manner. Based on this problem, AI have to dynamically predict potential defaults via exposure of rivals and market fluctuations.

The regulation of the derivatives industry is extremely difficult. Due to global participation, the derivatives market involves cross-border regulation, and the auditing of compliance required is very complex. Thus, the efficiency of manual review is poor. Hence, AI can conduct automated compliance checks, enabling it to quickly compare transactions to see if they comply with local regulations. AI can also identify abnormal transaction data or patterns to assist in supervision. Finally, as mentioned above, derivatives can be adjusted according to customer demands, which not only increases the difficulty of pricing but also requires traditional financial institutions to invest a way larger amount of human resources and money to customize hedging strategies. For solving this, AI can intelligently generate strategies and recommend the most ideal hedging plans based on the client's asset portfolio and risk preferences.

OTHER TECHNOLOGIES AND DERIVATIVE MARKETS

There are a lot of advanced technologies to promote the derivatives. Big data and advanced analytics can also be used to help price derivatives. Big data should first integrate massive amounts of data, extracting data from exchanges, brokers, news,

and social media to form a more comprehensive market view. For example, Deveikyte, Geman, etc. (2022) used natural language technology and analyzing specific news and companies, demonstrates that structured text data and sentiment analysis can add useful information to pricing or market trend prediction. Extreme scenario tests can also be conducted using big data-driven simulators to assess the risks of an investment portfolio under extreme circumstances.

Cloud or edge computing is highly powerful, as derivative pricing and risk management often involve complex Monte Carlo simulations, and cloud computing can significantly reduce computation time. Dong (2020) illustrated that the use of python and Monte Carlo simulations acclerated by GPU make it is possible to price the derivatives in the real time. Whereas, in the high-frequency trading (HFT) scenarios where ultra-low latency is required, edge computing can reduce delays and enhance execution speed.

Based on the Emmanuel, Kemevor, etc. (2025), The Internet of Things (IoT) can track the transportation status of commodities such as oil in real time through IoT devices, which enhances the credibility and transparency of the delivery process, thereby mitigating information asymmetry and liquidity risks, which finally strengthens the pricing and risk-hedging capabilities of derivatives.

DRAWBACKS OF TECHNOLOGIES

Nothing is perfect in this world including the technologies mentioned above. The first problem is the safty about the blockchain techonologies. The development of blockchain is uncomplete. Therefore, derivative contracts on the blockchain are irreversible. Once the code is leaked, the security of funds cannot be guaranteed. For instance, Berkowitz, Michels, etc. (2025) reported that the world-leading cryptocurrency exchange bybit was robbed of up to 1.5 billion dollar in this year. And such cases still occur very frequently, in sharp contrast to the safety of traditional financial institutions, which may drive a decline in customers' trust in platforms like dYdX.

Beyond that, the accuracy of AI is widely questioned. First, ChatGPT performs badly at handling large datasets and real-time data. Lanoue (2025) mentioned that the amount of data processed per run is limited for ChatGPT since its framework is designed to be an interlocutor rather than a data processing device. Considering how big amounts of news needs to be read to secure the reliability in this model, ChatGPT may not perform well. Besides, Lanoue (2025) also criticised ChatGPT cannot handle real-time data as it runs on static data sets and can only access recently updated data. When analysing news content in this model, it is possible to make misleading or outdated decisions due to a lack of access to the latest stock data or related information. Swayne (2021) also showed that AI has insufficient ability to correctly process or judge when facing clickbait headlines. Therefore, ChatGPT may be misunderstood by some clickbait headlines when filtering news, reducing the reliability of the results. The problems of overfitting and poor explanatory power may happened on AI, which may indicate that the current capabilities of AI may not fully support the description above.

The third one is the issue of time cost. The cost of deploying IoT, blockchain, and AI systems is huge, and it takes a considerable amount of time to reduce the average cost. The government may question the reform of the derivatives industry. Meanwhile, it is capable to monitor the trading is legal or not via AI, but AI itself is very easy to be manipulated, which makes black box operations possible. Similarly, corresponding legal and regulatory authorities are needed to supervise the use of blockchain and AI.

CONCLUSION

This article mainly introduced how can the blockchain, AI and some other technologies can boost the development in the derivative markets, and the corrsponding risks or bugs. Under the considerations that blockchain technology and AI are still not mature, the derivatives industry still needs a lot of time to wait for the further development and practical application of these technologies. It is worth affirming that these technologies undoubtedly offer the derivatives industry a promising future to look forward to. Potential directions for future studies include the combination of future technologies with derivatives, the difficulties in market promotion after the integration of technology and the derivatives, and the questions like how to minimize the risks of the technological shortcomings mentioned above, therefore safeguarding the rights and interests of customers.

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