Narrative Review Article

The Impact of Artificial Intelligence Advancements on the Frequency and Severity of Flash Crashes in Financial Markets

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ABSTRACT

Flash crashes, sudden, severe market price dislocations followed by rapid recovery, reflect the growing influence of automation in financial trading. Since the 2010 event that erased nearly one trillion dollars in value within minutes, markets have become increasingly dependent on algorithmic and artificial intelligence (AI)driven systems. This narrative review examines how recent AI advancements, including machine-learning–based prediction and autonomous execution models, influence the frequency and severity of flash crashes. Evidence from empirical studies indicates that AI improves trading speed, liquidity, and efficiency but simultaneously amplifies systemic vulnerabilities through algorithmic clustering, herding effects, and opacity in decision-making. While regulatory mechanisms such as circuit breakers and the SEC's Limit-Up/Limit-Down Plan mitigate immediate volatility, persistent challenges remain in transparency, governance, and ethical oversight. The review concludes that AI's ultimate effect on financial stability depends on the balance between innovation and regulation, whether algorithmic intelligence becomes a stabilizing safeguard or a catalyst for new forms of market disruption.

Keywords: AI; Stock Markets; Flash Crashes; Advancements; Severity

INTRODUCTION

The evolution of stock markets reflects a continuous drive toward efficiency through technological advancement. Early forms of trading emerged in medieval Europe, when moneylenders exchanged debts and commodities, but the modern stock exchange began with chartered companies such as the Dutch and British East India Companies. The introduction of joint-stock companies allowed investors to pool resources, spread risk, and generate profits, laying the foundation for organized markets. As industrialization expanded, so did the demand for capital and more formalized trading systems. In the eighteenth century, American brokers founded the New York Stock Exchange (NYSE), which quickly became a symbol of financial modernization and economic growth. However, as the scale and speed of markets increased, so too did their exposure to systemic shocks, as seen during the Great Depression. These early developments set the stage for the digitization of finance.

The creation of NASDAQ in the 1970s marked the first major step toward electronic trading, enabling transactions to occur through computer networks

rather than trading floors. This shift dramatically increased market accessibility and volume, connecting global investors through online platforms. As digital technology progressed, algorithmic trading strategies were introduced, and by the early 2000s, automation had become a defining feature of financial markets.

The next major phase of innovation arrived with high-frequency trading (HFT). Using powerful servers and complex algorithms, HFT enabled traders to analyze market data and execute transactions within microseconds. These systems exploited minimal price discrepancies between markets, enhancing liquidity but also magnifying systemic risk. The ability to trade at unprecedented speed meant that small technical or informational disturbances could cascade into large-scale market instability.

This growing dependence on automation became evident during the 2010 "Flash Crash," when the Dow Jones Industrial Average fell nearly 1,000 points in under ten minutes before rapidly recovering. The event revealed the vulnerability of interconnected algorithmic systems and demonstrated how rapid, automated responses could amplify volatility beyond human control. Although regulators implemented circuit breakers to contain similar disruptions, the incident underscored how technological progress could both enhance and endanger market efficiency.

In recent years, artificial intelligence (AI) has added another layer of complexity. Unlike earlier rule-based algorithms, AI models can learn and adapt to new data, predict market trends, and autonomously execute trades. These capabilities improve decision-making and risk assessment but also introduce opacity and the potential for collective algorithmic behavior, where multiple systems respond similarly, accelerating volatility. Each technological advancement,from early digitization to HFT to AI, has increased market automation, efficiency, and interconnection, while simultaneously heightening systemic risk.

Accordingly, this paper investigates how advancements in AI, led by major technology companies such as Google, Microsoft, and NVIDIA, influence the frequency and severity of flash crashes in modern financial markets. By examining both the benefits and risks of AI integration, the analysis seeks to determine whether continued innovation will stabilize markets or create new vulnerabilities in global financial systems. This paper also synthesizes findings from peer reviewed research, regulatory reports and financial analysis to bring forth a strong consensus.

AI-BASED MODELS: THEORETICAL FOUNDATIONS

Flash crashes, sudden, severe price dislocations followed by rapid recovery, have been examined through several modeling frameworks that explain their underlying mechanisms. These include Agent-Based Models (ABM), the Ultrafast Machine Ecology perspective, and Market Manipulation/Spoofing analyses.

Agent-Based Modeling (ABM)
ABM simulates interactions among heterogeneous traders, such as fundamentalists, chartists, and high-frequency traders (HFT). Studies by Gao *et al*. (1) show that synchronization among automated traders widens bid–ask spreads and can trigger liquidity gaps that lead to flash crashes. These models demonstrate how microscopic trading decisions aggregate into macroscopic instability.

Ultrafast Machine Ecology
Johnson *et al*. (2) describe an "ultrafast machine ecology" in which thousands of sub-second price movements occur beyond human response time. This framework suggests that algorithmic clustering, when multiple AI or HFT systems react to similar signals, amplifies volatility and propagates cascading sell-offs.

Market Manipulation and Spoofing
Empirical investigations such as those of the Navinder Sarao case illustrate how deceptive order placement ("spoofing") exploits automated responses to create artificial demand, supply imbalances. Levine *et al*. (3) emphasize that these manipulative strategies reveal the vulnerability of machine-driven markets to exploitation. Together, these three frameworks establish the conceptual foundation for understanding how AI and algorithmic trading can generate, amplify, or mitigate flash-crash phenomena.

EVOLUTION OF MARKET AUTOMATION

The increasing automation of financial markets has reshaped how trading occurs and how risk propagates. Early digital platforms such as NASDAQ enabled computer-based order matching, paving the way for algorithmic trading and high-frequency trading (HFT). These systems allowed transactions to occur within microseconds, improving liquidity while simultaneously heightening the potential for systemic instability.

Studies such as Gao *et al.* (1) in *Journal of Artificial Societies and Social Simulation* demonstrate that HFT narrows bid–ask spreads during normal periods but widens them during rapid sell-offs, creating flash crash conditions. Similarly, Johnson *et al.* (2) in *Scientific Reports* describe an "ultrafast machine ecology" where automated feedback loops exceed human response time, triggering volatility spikes.

The 2010 Flash Crash exemplifies this fragility. A single algorithmic sell order of E-Mini S&P contracts caused the Dow Jones Industrial Average to drop nearly 1,000 points within minutes. Leal *et al.* (4) found that synchronization among trading algorithms magnifies price dislocation, reinforcing how automation can both enhance and endanger liquidity. Each phase of market automation,from electronic trading to HFT,has increased speed and efficiency but also reduced transparency, making intervention more difficult when errors cascade.

AI'S INFLUENCE ON LIQUIDITY AND VOLATILITY

Artificial intelligence extends automation by introducing self-learning models capable of analyzing enormous data sets and autonomously executing trades. Empirical work published in *Quantitative Finance* and *Journal of Financial Markets* indicates that AI-enhanced trading generally improves market efficiency but also introduces new forms of correlation risk.

Abbas *et al.* (5), writing for the International Monetary Fund, argue that AI-driven funds improve execution quality yet amplify herd behavior when models react to similar inputs. Cowen (6) contends that diversity in model design can mitigate this effect, highlighting the importance of regulatory oversight to preserve model heterogeneity. Levine *et al.* (3) found that during the 2014 Treasury Bond Flash Crash, machine-driven liquidity evaporated almost instantly, suggesting that automation can both create and destroy liquidity depending on signal synchronization. Together, these studies reveal an emerging consensus: AI improves market function under stable conditions but accelerates volatility once automated reactions align across trading platforms. Beyond technical performance, AI in finance raises ethical and governance concerns. Algorithmic decision-making often lacks explainability, challenging both investor confidence and regulatory accountability. Transparent auditing frameworks, requiring documentation of model logic, data provenance, and testing, are increasingly viewed as essential for sustaining trust.

Without such standards, opacity could allow unintentional bias or manipulation to go undetected, undermining market integrity.

REGULATORY COUNTERMEASURES

Following the 2010 Flash Crash, the U.S. Securities and Exchange Commission implemented the Limit-Up/Limit-Down (LULD) Plan, pausing trades when a security's price moves outside predetermined thresholds. Similarly, the European Union's MiFID II directive requires volatility interruption mechanisms that halt trading when prices deviate excessively. These frameworks aim to provide markets with a "cooling period" that limits herd-driven instability.

However, scholars note that static circuit breakers cannot fully address the complexity of AI-based trading. Levine *et al.* (3) recommend integrating continuous monitoring systems that use machine learning to detect anomalies in real time. Such "AI supervising AI" approaches could predict and prevent flash crashes rather than merely reacting to them. Regulation must also ensure accountability for automated systems. Proposed "algorithmic accountability" policies require firms to record decision pathways, audit data inputs, and certify that models comply with fairness and transparency standards. Strengthening these safeguards is vital for maintaining investor confidence as AI assumes a larger role in market decision-making.

ADVANCEMENTS IN AI

Corporate innovations such as Google's Vertex AI, Microsoft's Copilot, and NVIDIA's GPU-accelerated analytics have significantly altered financial decision-making. Rather than serving as mere productivity tools, these platforms support large-scale data modeling, risk prediction, and trade automation. For instance, banks employing Copilot integrate natural language interfaces that summarize portfolio risk, while hedge funds using Vertex AI execute predictive modeling at greater scale. These systems enhance efficiency but also increase dependency on proprietary algorithms whose inner workings remain opaque to regulators.

CONCLUSION

The history of flash crashes and the rise of AI in trading show a double-edged effect: while technology

improves market efficiency, it also introduces new risks. The 2010 flash crash revealed how high-frequency trading could destabilize markets within minutes, and today's AI-driven systems push these dynamics even further. AI provides major benefits, including faster decision-making, improved risk management, and better market liquidity. However, its opacity, speed, and tendency to create herd behavior raise the risk of sudden volatility. Retail investors remain especially vulnerable, while institutions equipped with advanced AI tools are better positioned to recover quickly, deepening market inequality. Regulatory tools like circuit breakers help limit immediate damage but do not address underlying causes. As AI models continue to grow in complexity, regulators face the challenge of ensuring transparency, accountability, and stability in increasingly automated markets. At the same time, AI could also be part of the solution by detecting abnormal trading activity and helping prevent future crashes. Ultimately, the impact of AI on flash crashes depends on whether financial innovation is matched by effective oversight. Without safeguards, AI may amplify volatility; with them, it has the potential to enhance both stability and investor confidence. If strong safeguards and transparency requirements are implemented, for example, rules that require explainability for trading algorithms, better-tuned circuit breakers and AI systems that monitor each other for abnormal behaviors. With this, AI could stabilize markets, flag potential crashes early, and help protect both institutional and retail investors. However, there can be a chance that safeguards lag behind, innovation and proprietary models can remain opaque, AI may amplify volatility, triggering rapid selloffs that can outpace human intervention.

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CONFLICT OF INTERESTS

Yashica Mahajan declares that there are no conflicts of interest regarding the publication of this article.

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