Abstract: This study evaluates the effectiveness of advanced quantitative techniques, Monte Carlo simulations, AI-driven models, and Genetic Algorithms in enhancing investment portfolio management beyond Traditional Modern Portfolio Theory limitations. Analysing financial data from 2014-2024, this study assessed performance using Sharpe Ratio, Value-at-Risk, and Conditional Value-at-Risk across various market scenarios including black swan events. Findings demonstrate that Genetic Algorithms achieved the highest risk-adjusted returns while minimizing volatility, AI-driven models provided superior adaptability to market fluctuations, and Monte Carlo simulations significantly improved risk assessment compared to traditional approaches. The integration of green bonds into AI-optimised portfolios successfully balanced financial performance with sustainability objectives, appealing to environmentally conscious investors. This research confirms that AI and Genetic Algorithm approaches consistently outperform traditional models in optimising risk-adjusted returns under volatile conditions. Portfolio managers should consider implementing hybrid quantitative approaches that combine AI-based decision-making with Monte Carlo stress testing to enhance investment resilience and strategic planning in dynamic financial environments.