RESEARCH ARTICLE

A Review of Big Data Applications within the Financial Services Sector

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ARTICLE INFO	ABSTRACT
  *Corresponding Author: lee@ums.edu.my	Big Data has become one of the most popular topics across several industries, with companies looking to leverage its capabilities to extract valuable insights regarding their business operations and boost their competitive advantage in the market. The term big data implies a considerable amount of structured and/or unstructured data. In the financial sector, hundreds of millions of transactions are executed daily, offering vast opportunities for extensive data applications. However, the sheer amount of data can be very challenging to process, and it is doubtful for an analyst to be able to review an entire raw data set. This compels analysts to narrow their scope, focusing on acquiring valuable and actionable business insights for critical decision-making and strategies. This paper will explore some critical metrics and the latest use cases of big data analytics within the broader financial services sector.

INTRODUCTION

With the advancement of information technology, various data types are available through new technological innovations. Data has become one of the most valuable commodities in every industry and an integral element in strategic business decisions for various use cases, including analyzing and forecasting trends, performance monitoring, product optimization, customer acquisition, retention, and many more (Al-Ajlouni, 2018). The use cases of big data are constrained by the creativity and capabilities of the data handler. Of course, with the abundance of information available today, it is often straightforward to lose sight of the main objectives when there are so many variables to look at. This issue also occurs along with technological advancements (Cockcroft and Russell, 2018). For example, the advancement of Internet of Things (IoT) technologies increases the velocity, volume, variety, and validity of data collected daily from the sensors. This phenomenon also occurs in the financial industry since there have been many popular big data applications adopted by both traditional and non-traditional financial institutions.

To gain a comprehensive understanding of this paper's research topic, it is pertinent to discuss a few of the industry jargon relevant to this research, such as financial institutions (FIs), Fintech, robo-advisors, cryptocurrency, and blockchain. Financial institutions

(FIs) refer to an entity or organization that engages in the business of financial transactions, including, but not limited to, deposits, loans, investments, and currency exchange. Financial institutions today include traditional banks and many new, emerging Fintech companies. Meanwhile, Fintech is a term coined from the combination of the words "finance" and "technology", which refers to the application of new information technologies and innovations related to financial operations (Hasan et al., 2020). Robo-advisors are digital platforms that offer automated, algorithmic investment services with minimal human intervention. A relatively new segment in the industry that has risen in popularity over recent years, thanks to the adoption of Fintech, Cryptocurrency is a new asset class that is challenging the traditional banking infrastructure and financial markets. A cryptocurrency is a digital currency secured by cryptography, making it nearly impossible to counterfeit. Many of these cryptocurrencies operate on a decentralized blockchain network. Lastly, a blockchain is a distributed ledger or database shared among the nodes of a computer network. The blockchain stores data and information electronically in digital format.

This study explores the potential of big data applications, especially in the financial service sector, since finance is one of the main components determining a country's development. This study could assist the government, educators, researchers, industry, and society in understanding the potential of big data applications based on the industry's report and recent research. It serves as a panoramic view of the topic, combining outcomes from both industry and research. The government could consider investing in this area to develop the country's economy. An educator could reference this study's result in their teaching process. Researchers can continue this study by developing a theoretical framework for big data applications in the service sector. By implementing the summarized research from different resources, industry and society could benefit from this study.

METHODOLOGY

The narrative review method is used in this study to discover the latest developments in this specific topic: big data in financial markets (Baumeister and Leary, 1997). Articles and electronic sources such as websites, organization reports, and books that reveal the state of the art of the topic are retrieved through the main search engines, Google and Google Scholar. Keywords such as big data, financial markets, financial services, big data application, big data analytics, metrics, decision making, Fintech, robo-advisor, cryptocurrency, and blockchain are used in searching the resources. Thousands of materials are then filtered through titles and abstracts. Only the latest (within 5 years) materials are reserved for the next step: reading and summarization.

BIG DATA IN FINANCIAL MARKETS

Financial markets refer broadly to any marketplace that trades securities, including but not limited to the stock market, bonds, forex, derivatives, and cryptocurrency (Zucchi, 2022). These assets are typically listed on regulated exchanges or traded Over The Counter (OTC). The primary fundamental function of financial markets is to allow efficient allocation of capital and assets in the financial economy.

Engaging in asset trading is typically performed diligently, with extensive research conducted before executing a transaction. This makes asset trading a challenge in the increasingly dynamic environment of financial markets, involving constant changes in price action due to many kinds of internal and external variables (Best, 2022). Social networks are playing a crucial role in financial markets today, generating millions of pieces of information worldwide. The search frequency of specific keywords, such as a stock name, helps traders gauge the market sentiment towards a specific stock or industry. This method is a form of data mining technique called indexing.

Meanwhile, significant data use cases in today's financial markets can be seen in multiple forms, including return predictions, volatility forecasts, market valuations, risk analysis, portfolio management, index performance, algorithmic trading, etc. (Giebe, 2022; Indriasari et al., 2019; Bahrami et al., 2020). Big data offers different methods of financial analysis for corporate finance, reducing equity uncertainty and reducing the cost of forecasting related to a financial decision for a firm. By forecasting future returns, investors can reduce uncertainty about

their investment outcomes and adjust their risk level accordingly. Costs are also reduced as investors can process more data, enabling firms to scale and grow larger. With big data, a new transformative environment sets the stage with innovative financial technologies that help process large datasets with relatively significant speed and accuracy (Hasan et al., 2020; Sun et al., 2020).

Types of investment analysis

There are multiple methods to analyze the financial market and securities. Some analyses are used to select the appropriate securities depending on macroeconomic factors and risk levels. Analyses are also used to select the timing to enter or exit a market. Within the scope of this paper, we will explore the most popular and basic types of approaches.

Top-down and bottom-up analysis: Both approaches are used to analyze and select securities but with distinct differences. Top-down is often understood as going from general to specific and is often associated with 'macro'. Macroeconomics is an area that looks at the most significant factors affecting the global economy, including federal fund rates, unemployment rates, gross domestic product, and inflation rates (Murphy, 2022).

The bottom-up analysis takes a vice-versa approach, focusing on starting with the specifics and micro-perspectives. This approach concentrates on business-by-business or sector-by-sector fundamentals to identify profitable opportunities in price and market valuation (Murphy, 2022). Most bottom-up investors typically have a strong understanding of the securities' fundamentals.

Fundamental and technical analysis: Fundamental and technical analysis are often considered at opposite ends of the spectrum in their approach to the market. Fundamental analysis evaluates securities by attempting to measure their intrinsic value. This approach looks to study the overall financial strength of security while considering the overall economy and industry conditions. Company earnings, expenses, assets, and liabilities are the main pillars of the fundamental analysis (Majaski, 2022).

Technical analysis, often abbreviated as 'TA', attempts to identify opportunities by looking at data points and statistical trends in a stock's price movement and volume. TA does not attempt to measure intrinsic value but instead uses charts to identify patterns and trends that suggest potential future outcomes (Majaski, 2022). Popular signals in TA include support and resistance levels, simple moving averages (SMA), and momentum indicators.

The application of big data analytics tools in investment analysis

There are many different types of big data analysis involved in financial markets. Experts in their respective fields typically carry out these analyses. However, no matter how knowledgeable or skilled the analytics team is, attempting to manually collect and analyze raw data on the financial markets is neither an effective nor efficient approach. Modern technologies now offer analysts big data analytics (BDA) tools to ease data mining and analysis (Carey, 2021). These tools have become a staple in today's investment analysis, including tools such as Bloomberg Terminal, Yahoo Finance, and, more recently, TradingView, mainly due to the rising number of retail traders and investors (Best, 2022).

Initially launched in 1981, even before the dot-com era, Bloomberg Terminal was designed to connect market stakeholders to real-time market data, powerful analytics, and communication tools (Kenton, 2022). It was designed to be the primary source of market information covering multiple asset classes, including fixed income, equities, foreign exchange, commodities, and derivatives, integrated into a single system and delivered in real-time to end users. Evolving from dedicated hardware to run the application, Bloomberg Terminal has since been replaced by a software-based solution that runs on any standard computer system. In other words, they have adopted a software-as-a-service (SaaS) model, a licensing and delivery model based on subscriptions. SaaS is an 'on-demand software' that allows users to choose the related scope of services and features for their specific requirements.

Another popular source of data and information among traders and investors today is Yahoo Finance. Like Bloomberg Terminal, Yahoo Finance offers real-time news and stock quotes, linkage to multiple brokers and portfolios, and interactive charts for performance monitoring (Zucchi, 2022). Yahoo Finance is also based on a SaaS model; the product comes in a free version with limited features and

higher-tier versions, offering end users access to additional advanced features. Some examples of additional features include enhanced charting tools and AI-based auto-pattern recognition. Yahoo Finance and the Bloomberg Terminal are tools used for many different types of analysis, including fundamental and technical analysis. The analyses offer analysts a better understanding of asset classes and their correlation to the macroenvironment. It further helps analysts make better and more informed investment decisions.

Tradingview was founded in 2011 but gained its cult-like status more recently due to the rise of cryptocurrency in 2017. Tradingview is a platform offering users highly advanced charting tools as its core product, with an intuitive user interface and a community of over 30 million investors and traders (Best, 2022). The platform also offers additional features through subscription packages. Cryptocurrency took the financial markets by surprise in 2017 and, more recently, in 2020, with several crypto assets outperforming traditional assets by a significant margin. According to Nasdaq, Bitcoin has a 10-year ROI of +437,171% compared to gold and the S&P 500 at -0.25% and +277%, respectively (Nasdaq, 2021). It is to be noted that cryptocurrencies are highly volatile in terms of price action. However, this risk offers traders many short-term opportunities. The trading view was heavily popularized by retail investors and day traders looking to conduct technical analysis (TA) on their assets of interest. The fundamentals of crypto assets differ from traditional asset classes, as they are entirely newly emerging. Many crypto investors today still need to learn about the fundamentals of specific cryptocurrencies. This is why TA quickly became a preferred approach to market involvement (Carey, 2021).

Table 1 summarizes the key findings of this section by comparing Bloomberg Terminal, Yahoo Finance, and TradingView in terms of pros and cons and the scenarios in which each technology should be applied.

Table 1: Pros and cons, and scenarios of using Bloomberg Terminal, Yahoo Finance, and Tradingview

Tool	Pros	Cons	Scenarios
Bloomberg Terminal	Comprehensive data News and analysis Customizable interface Communication features	Expensive Steep learning curve Limited mobility Proprietary system	Professional traders, investors, and financial analysts who need comprehensive and real-time data on equities, commodities, fixed income securities, and currencies. Users who require access to high-quality research, analysis, and news, and who need to communicate with other financial professionals in real-time
Yahoo Finance	Free User friendly Portfolio tracking News and analysis	Limited data Limited customization Advertising Limited communication features	Casual investors who are looking for a free and user-friendly tool to track their investments and portfolios. Individual investors who want access to basic financial data and news.
Tradingview	Comprehensive data Customizable interface Social networking features Mobile-friendly	Limited fixed income data Limited news and analysis Subscription fees Community-driven content	Traders who require a customizable platform that can be tailored to their specific needs, access to extensive data on equities, commodities, and cryptocurrencies, and who want to create their own analysis tools and strategies, collaborate online with other traders.

Artificial intelligence and investment framework
Before this study dives deeper into the AI-based investment framework, it would be beneficial to understand the fundamentals of portfolio management. An investment portfolio typically consists of different asset classes, ranging from equities to protecting assets such as fixed income and gold. These asset allocations are usually determined by the investor's risk profile and the related market conditions. Several long-term studies suggest that asset allocation accounts for between 80% and 96% of portfolio returns (StashAway, 2019).

There are many investment strategies that investors and traders could utilize, depending on their risk preferences and market conditions. In the previous section, this study explored how some big data analytics tools could help individuals or organizations analyze market data. However, the effectiveness and accuracy of these analyses are still dependent on human factors, such as the knowledge and capacity of the investment team. These approaches remain prone to human-related errors, including a lapse in judgment or even simply overlooking a few essential details. According to a US Scorecard, more than 90% of professional portfolio managers underperform their benchmarks relatively. This statement is not to highlight the underperformance of industry professionals but to show portfolio management's complexities. To overcome this issue, many new modern fintech companies have introduced the integration of artificial intelligence into their investment frameworks (Chartier et al., 2021).

Staff at traditional financial institutions such as large banks and global tech giants are increasingly leaving for fintech start-ups. Departures from traditional financial institutions such as Goldman Sachs Group Inc. and HSBC Holdings Plc are up 75%, with their talents opting to join fintech companies such as Revolut and Coinbase (Shaw, 2022). Revolut was founded in 2015, offering peer-to-peer payments and currency exchange. Coinbase was founded slightly earlier in 2012 and is currently one of the largest cryptocurrency exchange platforms today.

Fintech is a new segment comprising companies offering consumers various new digital financial solutions. Data and AI are merging into a synergistic relationship. Combining these two disciplines has shaped some of the core products of one sub-segment within the fintech landscape heavily associated with AI-based investment frameworks known as 'robo-advisors' or digital wealth managers. The term robo-advisor can be understood as a self-guided online wealth management service that provides automated investment to sophisticated or retail investors at low costs (Betterment, 2019). Many of the current robo-advisory frameworks are based on the Modern Portfolio Theory of Harry Markowitz, with a few usual tweaks. Markowitz's theoretical framework and mathematical modelling were awarded the Nobel Prize in 1990, resulting in improvements in portfolio strategy construction for many investors (Johnson and Ramaswamy, 2021). His insight was that any asset included in a portfolio should not be assessed by itself but rather analyzed as a contribution to the whole portfolio. The next section of this paper will explore the investment frameworks of three popular digital wealth management platforms: Betterment, Wealthfront, and StashAway.

Betterment: Founded in 2008, Betterment is an American-based financial advisory company with a business model that includes three main areas of business: retail investment, an advisory platform, and 401(k) for mid-market business. As of December 2021, Betterment had over USD 33 billion in assets under management (AUM) with a customer base of over 700,000 individuals (Johnson and Ramaswamy, 2021). The Betterment Investment Framework goes slightly beyond traditional, modern portfolio theory. They deemed five critical factors to be considered: estimating forward-looking returns, estimating covariance, tilting specific factors in the portfolio, accounting for estimation errors in the inputs, and taxes in taxable accounts. In layman's terms, Battement's framework aims to automate investment using algorithms that would continually monitor and manage portfolios throughout their product lifecycle. Their services include portfolio re-optimization and rebalancing, dividend reinvestment, and the ability to schedule recurring transactions, standard features most digital wealth managers offer today.

Wealthfront: Wealthfront is another American-based company founded during the same period as Betterment, with an AUM of USD 21 billion as

of September 2019 (Hamdan, 2022). Wealthfront and Betterment employ modern portfolio theory principles, yet with some modifications in their fee structures and the list of Exchange-Traded Fund (ETF) and product ranges offered. Wealthfront's core portfolio asset classes differ from Betterment, in which they added commodities, emerging market bond ETFs, and REITs. Investors with an AUM greater than $100,000 would also gain access to direct stock indexing to replace US stock ETFs. In terms of customization, Wealthfront allows customers to add individual ETFs to their portfolios, which is not available in Betterment. Despite some minor differences, Wealthfront's core investment framework shares similarities with Betterment, leveraging algorithms to manage portfolios at the group level.

StashAway: StashAway is a company founded in 2016 that pioneered the robo-advisor space in Singapore and Malaysia. By the end of 2020, they would have accumulated USD 1 billion in Assets Under Management (AUM). They launched their expansion into three new regional markets, including the United Arab Emirates (Middle East and North Africa Region), Hong Kong, and Thailand. The company's investment strategy is based on its proprietary framework called Economic Regime-Based Asset Allocation (ERAA), built with decades worth of academic research and the experience of many high-profile financial professionals. Their systematic approach avoids human biases and enables using thousands of historical data points in each portfolio construction decision (Sun et al., 2020). StashAway's algorithm monitors the factors that influence inflation and growth rates of change to indicate the economic regime. Four economic regimes in StashAway's framework are labelled good times: inflationary growth, stagflation, and recession. Asset classes tend to behave differently depending on the economic regime. ERAA aims to change a portfolio's asset allocation to prepare for the current or upcoming regime while maintaining the investor's risk preference.

Data and machine learning are transitioning into a synergistic relationship. Based on some of the investment frameworks explored above, the innovations derived from combining these two disciplines. Over the next few decades, there is a high possibility of a new financial landscape formation. More fintech technologies, such as blockchain, will be developed, which could elevate the traditional financial infrastructure. Big data will play a vital role in constructing investment frameworks in the financial markets.

Table 2 summarizes the key findings of this section about robo-advisors: Betterment, Wealthfront, and StashAway.

Table 2: Pros, sons and scenarios of Betterment, Wealthfront, and StashAway

Tool	Pros	Cons	Scenarios
Betterment	Offers a wide range of investment portfolios with varying levels of risk. Provides personalized financial planning and tax-loss harvesting services. Has low account minimums and fees. Offers a high-interest savings account.	The investment portfolios may be limited to only ETFs. The platform charges a higher fee for access to financial advisors.	Suitable for someone who is new to investing and wants a simple, easy-to-use platform that offers a range of diversified ETF portfolios. Also suitable for someone who wants access to financial advisors for personalized financial planning or tax-loss harvesting services.
Wealthfront	Offers a wide range of investment portfolios, including ones that are tailored for retirement savings. Provides personalized financial planning and tax-loss harvesting services. Has low account minimums and fees. Offers a high-interest savings account.	The investment portfolios may be limited to only ETFs. May not have as many portfolio options as Betterment or StashAway.	Suitable for someone who is primarily focused on retirement savings and wants a tailored portfolio designed specifically for that goal. Suitable for someone who wants access to financial planning services and tax-loss harvesting, and who values a high-interest savings account.
StashAway	Offers personalized portfolios tailored to individual risk profiles, goals, and time horizons. Provides a wider range of investment options, including ETFs and individual stocks. Offers low account minimums and fees. Provides a user-friendly platform with educational resources.	The investment portfolios may be more complex than those of other robo-advisors. The algorithm may require more user input and adjustment than other robo-advisors. The investment portfolios may have more exposure to international markets, which could result in more volatility.	Suitable for someone who wants a highly personalized portfolio tailored to their individual risk profile, goals, and time horizon. Suitable for someone who wants access to a wider range of investment options, including individual stocks, and who values a user-friendly platform with educational resources.

BIG DATA IN MANAGING FINANCIAL SERVICES

The financial industry is a broad term that includes many different financial activities. This section will look at some critical financial service management elements, including anti-money laundering (AML) and customer analytics.

Risk assessment and fraud detection

Anti-Money Laundering (AML) refers to the laws and regulations governing businesses to reduce and prevent financial crimes. The finance industry is typically heavily associated with compliance and regulations, with financial institutions (FIs) adhering to a strict set of rules set by their corresponding regional governing entities (Cockcroft and Russell, 2018). For instance, FIs and corporate entities in the US are governed by the US Securities and Exchange Commission (SEC) and the Federal Reserve System. FIs are required to acquire licensing to operate within the jurisdiction of the regulating entities. Failure

to adhere to the regulations and policies would result in the possible retraction of operating licenses, hefty corporate fines, jail time, or all of the above. Over the years, many high-profile compliance cases have been involving renowned FIs. For example, KPMG and Deloitte were investigated for possible compliance breaches in auditing standards about Malaysia's 1MDB scandal (Hamdan, 2022; Shukry and Ngui, 2021). Both parties agreed to a settlement of approximately USD 80 million each (Palani, 2022; Yamin, 2021).

With possible prosecutions and fines looming, the financial industry does (and should) not take compliance requirements lightly. FIs have invested substantially in designing and optimizing their AML frameworks and processes. Big data is known to be an ideal tool for this use case due to its automation and AI capabilities (Kaur et al., 2020). By design, AML mandates are rigid and inflexible, but there is

a considerable need to identify emerging patterns of suspicious activities. This section of the paper will explore how big data analytics can provide the insights and automation needed for a practical compliance framework.

Know-Your-Customer (KYC): KYC is a topic at the start of every FI's onboarding process, as they are responsible for ensuring that their customers are not at risk of participating in money laundering activities and that they are not on watchlists such as Politically Exposed Persons (PEPs) or sanctions lists. Machine learning and big data could make this process more effective and efficient by offering access to large databases and automating the ongoing screening process (Kaur et al., 2020). KYC does not end after completing the onboarding of a customer but is also conducted periodically to ensure that the available data is accurate and relevant.

Customer risk rating: As part of the onboarding due diligence requirements, customer risk ratings are assigned to every customer to indicate their level of risk. This risk rating is determined by many factors, including nationality, PEP status, previous legal cases, and many more (Kaur et al., 2020). This risk rating aims to ensure that the appropriate level of monitoring is given to customers. Customers with a PEP status or on a sanction list may be considered under extra due diligence as required by regulations.

Reducing false positives: The process of due diligence involves screening the customer's profile, which would inadvertently include some false positives from time to time. This screening process highly depends on the accuracy and availability of database information. If the reference database is outdated, this may result in the system flagging out correlations that may not necessarily be accurate anymore. According to a study, the alerts created by AML programs are primarily false positives (Kaur et al., 2020). Big data offers real-time analytics capabilities that reduce false positives. Rules and requirements settings in the analytics can also be easily adjusted with machine learning and advanced analytical tools.

Transaction monitoring: Transaction monitoring is a core component of the AML program, which examines the financial transactions of customers and flags any suspicious activity (Kaur et al., 2020). With hundreds of thousands of transactions happening every hour,

this dataset is increasingly becoming more significant daily. This, however, does not imply that FIs need to increase their workforce to match the numbers but could also be more efficiently achieved through machine learning. Specific business rules can be put in place to flag certain activities. For instance, an analyst could set a rule to flag high-risk or unusually repetitive transactions.

Case management and reporting: Reporting suspicious activities is a mandatory regulatory requirement for FIs. The business must investigate and report the findings to their governing entity when suspicious activity is identified. In the US, businesses must fill out suspicious activity reports (SAR) and send them to FinCen. Case management and reports are typically time-consuming, but some big data analytics tools today offer users many new features to ease the process (Kaur et al., 2020). The tool also simplifies the data extraction process and provides advanced data visualization tools.

Customer analysis and marketing

Through data science, analyzing real-time data is now possible and simpler than ever before. Financial services can now respond to trends quickly and make critical business decisions to get ahead of competitors. Some examples of these real-time analytics include geofencing, geotargeting, and beaconing. Real-time analytics are beneficial for understanding consumer behavior. In a highly competitive market, as with the financial industry, FIs need to know their consumer demands as quickly as possible to implement appropriate marketing campaigns and align their business objectives (Chartier et al., 2021; Hung et al., 2020). For example, banks could study their past interactions with customers to determine the demand for their product line. A specific savings account is preferred by a segment of customers. Banks could target this segment through marketing campaigns and boost the product's user base.

For this specific use case, the popular solution for almost every industry is to use a customer relationship management (CRM) tool (Hossain et al., 2021; Sasso, 2022). A CRM tool is the platform to manage all the company's relationships and interactions with existing and potential customers. Many CRM providers offer advanced analytical features today, including seamless system integration

with multiple media channels, business tools, and payment systems (Chartier et al., 2021). Some examples of popular CRM tools today include Salesforce, Zendesk, Freshdesk, and many more. Most of these tools employ a SaaS model with a varying subscription level depending on the business's needs. This allows financial services to scale up or down the requirements of SaaS with flexibility.

Table 3 concludes some challenges in anti-money laundering, know-your-customer, customer risk rating, reducing false positives, transaction monitoring, case management, and reporting—the big data analytics.

Table 3: Challenges in big data analytics in managing financial services

Challenges	Description	Financial Services
Data Quality	Ensuring that the data used for analysis is accurate, complete, and up-to-date. Poor data quality can lead to incorrect results, false positives, and other errors	AML, KYC, CRR, RFP, TM, CMR
Data volume	Big data sets are often very large, making it difficult to store, process, and analyze the data. This can be a major challenge for organizations with limited resources	AML, KYC, CRR, RFP, TM, CMR
Data integration	Many organizations have data stored in multiple systems and formats, making it difficult to integrate and analyze the data effectively	AML, KYC, CRR, RFP, TM, CMR
Data privacy	The use of customer data purposes raises concerns about data privacy and the need to protect sensitive information.	AML, KYC
Regulatory compliance	Compliance with AML regulations and guidelines can be complex and time-consuming, requiring a significant investment in resources and technology.	AML
Lack of expertise	Big data analytics requires specialized skills and expertise, which can be difficult to find and expensive to hire.	AML, KYC, CRR, RFP, TM, CMR
False positives	False positives can be a significant challenge in AML and KYC, leading to wasted time and resources and potentially missing real instances of money laundering or fraud.	AML, KYC
Interpretation of results	The results of big data analytics can be complex and difficult to interpret, requiring skilled analysts to make sense of the data and identify meaningful insights.	AML, KYC, CRR, RFP, TM, CMR
Technical infrastructure	Organizations need to invest in the right technology infrastructure to effectively store, process, and analyze large amounts of data.	AML, KYC, CRR, RFP, TM, CMR
Cost	Implementing big data analytics for AML and KYC can be expensive, requiring a significant investment in technology, people, and processes.	AML, KYC

Note: AML-Anti-Money Laundering, KYC-Know-Your-Customer, CRR-Customer Risk Rating, RFP-Reducing False Positives, TM-Transaction monitoring, CMR-Case Management and Reporting

CONCLUSION

The use cases of big data are ever-growing. The vast amount of data available can become very daunting to explore if we are unaware of some standard industry use cases. For the scope of this paper, we have looked at a few specific big data applications in the context of the current financial landscape, including big data tools for investment analysis, AI-based investment frameworks, AML processes, and customer analytics. This barely scratched the surface of its full capabilities. Big data will continue to be further developed, and many of the components explored today will undoubtedly evolve with the advancement of the field. Collaboration between academia, research, and industry will accelerate the advancement of big data analytics in financial services. Challenges such as data

confidentiality, privacy, and security will require the involvement of the country's government and even the active involvement of a global entity. Nevertheless, big data analytics has a high potential for enhancing financial services.

Recommendations and implications

The advancement of the Internet of Things (IoT), ChatGPT, AI, and blockchain is closely related to big data analytics. The technologies impel the development of the metaverse, which creates another living dimension for humans. People live, interact, and transact in virtual and augmented reality worlds. Thus, big data analytics is crucial in ensuring the accuracy of each transaction and business processing in the metaverse, which combines several technologies and a data warehouse in the moving metaverse. This study starts an entry into financial services in the metaverse by exploring the possibilities of significant data analytics implications for ensuring service quality, whether in the physical or virtual world. It is recommended by the authors to further study various fields of big data analytics in financial services to realize virtual financial services in the metaverse.

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