Int J Syst Assur Eng Manag (December 2023) 14(6):2048–2065
https://doi.org/10.1007/s13198-023-02123-8

REVIEW PAPERS

A bibliographic overview of financial engineering in the emerging financial market

Jyoti Ranjan Jena[1] · Saroj Kanta Biswal[1] · Avinash K. Shrivastava[2] · Rashmi Ranjan Panigrahi[3]

Received: 10 March 2023 / Revised: 22 July 2023 / Accepted: 24 August 2023 / Published online: 14 September 2023

Abstract Financial engineering is constantly changing and encountering new problems. Financial engineering helps us detect emerging trends and challenges, such as fintech's effect on banking institutions or environmental change, and design novel solutions. Still, many areas remain open to exploring the contribution of FE research in finance. This study has adopted combined qualitative research approaches through bibliometric analysis. The research was conducted from 2007 to 2022. Study findings and conclusions are supported by an analysis of bibliographic coupling, co-occurrence & co-citation of 343 research publications taken from the Scopus database, and analysis was performed using software tools such as VOS-Viewer and Biblioshiny with R Studio. Based on the results of these analyses, the study was able to conclude the trends and characteristics of research on financial engineering in the financial market. The **s**tudy identifies prominent authors, journals, and institutions using bibliometric analysis. The current study highlighted the most cited research articles and identified the seven most emerging thematic clusters. The originality extracted from research findings compels and motivates extensive research in FE in the future. The emerging areas and themes identified from the study, i.e., (1) FE and adoption of AI & IOT Applications for RM, (2) investment decision and business crisis, and (3) recent developments and mathematical application in risk analysis. The novelty of the study lies in its focus on financial engineering in emerging financial markets, the adoption of a bibliographic overview methodology, the integration and evaluation of previous research, the identification of trends and research gaps, and its value as a resource for researchers and practitioners. These aspects make it a unique and valuable contribution to the field of financial engineering.

Keywords Bibliographic coupling · Bibliometric analysis · Co-citation · Co-occurrence · Financial engineering · Financial market

✉ Rashmi Ranjan Panigrahi
rashmipanigrahi090@gmail.com

Jyoti Ranjan Jena
jyotiranjanj622@gmail.com

Saroj Kanta Biswal
sarojkantabiswal@soa.ac.in

Avinash K. Shrivastava
kavinash1987@gmail.com

[1] Faculty of Management Sciences, IBCS, Siksha "O" Anusandhan Deemed to Be University, Bhubaneswar, Odisha, India

[2] International Management Institute Kolkata, West Bengal, India

[3] GITAM School of Business (Operation and Finance), GITAM Deemed to Be University, Visakhapatnam, Andhra Pradesh, India

1 Introduction

The relevance of FE in the financial industry is growing because it offers investors the tools and strategies necessary to manage risk and make investment decisions based on accurate information (Dushnitsky and Lenox 2006). It has also made it possible for financial institutions to offer new goods and services that are more complex and can be customized to match the individual requirements of the customers who use such institutions (Alshubiri et al. 2020; Oztemel and Gursev 2020). The relevance of FE in the financial sector is growing because it offers investors the methods and skills necessary to manage risk and make investments based on accurate information. It has

also made it possible for financial institutions to offer new goods and services that are more complex and can be customized to match the individual requirements of the customers who use such institutions (Rahman et al. 2022). In the 1970s, this field evolved due to the growing complexity of financial markets and the necessity for more advanced strategies to manage financial risk (Zopounidis et al. 2010). Modeling and techniques for understanding and controlling financial risk are developed by FE using a wide variety of disciplines, including developments.

To keep track of the most recent advancements in a certain field, this study uses the numerous advantages and tried-and-true methodologies offered by bibliometrics. For instance, the interconnected "co-citation network" of national publications, the authors' "co-occurrence network" and "keywords", an article's "co-citation" network, as well as burst detection & timeframe visualization, are all able to be graphically represented (this technique is also known as science mapping analysis) and "VOS-Viewer" are among the significant visualization techniques available (Li and Xu 2021; Safta et al., 2021). By conducting a systematic literature selection and in-depth bibliometric analysis, the research objective was to solve the following research issue in FE and finance. The unique contribution of the study was addressed through bellow research questions.

RQ-1: What are the most frequently referenced articles in the financial engineering literature?

RQ-2: Who made significant contributions to the discipline of financial engineering, based on their impact and influence within the field?

RQ-3: What are the most prestigious publications and the prevalent themes in the field of financial engineering?

The study's strategy of presenting a bibliographic overview offers uniqueness by integrating and assessing existing research. It can uncover trends, research gaps, and areas of interest within the use of financial engineering in emerging financial markets by methodically analyzing and summarising past works. This overview can be a great resource for scholars, practitioners, and policymakers looking to grasp the subject's current state and identify future paths. The motivation for A bibliometric study on financial engineering can provide significant insights and contribute to the growth of knowledge on the innovative instruments and trading practices adopted in recent times. Bibliometrics can aid in determining the quality and effect of academic journals and conferences in financial engineering. By studying publishing and citation patterns in various venues, researchers can make informed judgments about where to publish their work and where to discover relevant and high-impact research in the financial market. In addition, the current research identifies novel financial engineering applications or methods for dealing with emerging markets. These results can potentially expand our current body of knowledge and motivate further exploration.

The remaining components of this study article are structured: part 2 covers the history of Financial Engineering, part 3 covers the most recent developments in FE research, part 4 covers the methodology of the study, part 5 covers the conclusions of the research, and part 6 covers the contribution, future scope and concluding remark of the study.

2 An introduction to financial engineering background

2.1 Definitions of FE

FE explains that the process of designing and developing new financial instruments and strategies through mathematical tools is referred to as financial engineering (Yuan and Wang 2019). Financial engineering uses mathematical techniques to create new financial instruments and solve existing financial problems (Liu et al. 2006). Derivatives, structured products, and collateralized debt obligations are just a few examples of complex financial products and services that may be developed with the help of financial engineering. Increasingly sophisticated financial solutions that may be adapted to the individual needs of investors and borrowers have been made possible because of financial engineering (Abad-Segura et al. 2020). The financial markets and the field of financial engineering are intrinsically linked (Kumar et al. 2020). The financial markets serve as a laboratory for the models and tactics developed by financial engineers, and they also provide the platform upon which the currently stable financial engineers can be implemented. As a result, financial engineers can get the information they need to model and assess financial risks and returns with the help of financial markets (Singla and Luby 2020).

2.2 Financial engineering in emerging financial market

Financial engineering is gaining prominence as a significant discipline within the financial market due to various factors. These include the increasing complexity of the financial landscape, with a diverse array of instruments, products, and strategies. Financial engineering addresses this complexity by developing innovative solutions to manage risks, optimize portfolios, and unlock new investment opportunities. Technological advancements, particularly in computing power and data analytics, have also played a pivotal role in the rise of financial engineering (Sardana and Singhania 2018). These advancements enable the application of sophisticated mathematical models and algorithms in financial decision-making. Financial engineering leverages these technologies to analyze vast datasets, construct pricing models, and

implement effective trading strategies. Risk management has become a critical aspect of financial operations, and financial engineering plays a vital role in this domain (Kafidipe et al. 2021). By developing risk models, derivative products, and hedging strategies, financial engineering helps institutions mitigate different types of risks, including market risk, credit risk, and operational risk. Moreover, financial engineering contributes to the development of advanced investment strategies (Folqué et al. 2021) that aim to generate superior returns while effectively managing risk. These strategies often involve leveraging complex derivative instruments, quantitative models, and algorithmic trading systems.

Financial engineering also fosters financial innovation by creating new financial instruments (Huang and Wang 2019), structured products, and investment vehicles. These innovations cater to the evolving needs of investors, offer access to alternative asset classes, and facilitate efficient capital allocation. Furthermore, the changing regulatory environment has increased the demand for risk management practices and transparency. Financial engineering techniques assist financial institutions in complying with regulatory requirements, optimizing capital utilization, and enhancing risk reporting (Johnston and Petacchi 2017). Therefore, the emergence of financial engineering within the financial market is propelled by the necessity for sophisticated tools and techniques to navigate the intricacies of modern finance, effectively manage risks, and create value for investors and market participants.

2.3 Developments and phase of financial engineering

Financial engineering is a relatively new field, rooted in the development of modern finance theory in the 1950s and 1960 (Libich and Lenten 2022). Here is a brief journey of financial engineering from inception to 2020:

The discipline of financial engineering has advanced greatly because of numerous notable breakthroughs and innovations over the years. From its inception in the 1970 through its anticipated maturity in 2020, financial engineering may be traced as follows:

Inception in the 1970: The "Black–Scholes model", a mathematical technique of pricing options, marked the beginning of financial engineering as a discipline in the 1970. The concept was crucial in the development of cutting-edge financial instruments, and it also facilitated a paradigm shift in the field of options trading.

The 1980: New financial products, including futures and swaps, were introduced in the 1980, allowing financial engineering to continue its evolution. Engineers in the financial sector have recently started employing sophisticated mathematical models for market analysis and risk management.

In the 1990: Financial Engineering continued to grow, creating new types of derivatives, such as credit default swaps and interest rate swaps. Financial engineers also began employing computer technology to evaluate market data and conduct trades.

In the 2000–2006: The decade of the 2000 witnessed the rise of algorithmic trading and high-frequency trading, both of which contributed to the development of financial engineering. The process of analysing market data and developing trading platforms has become more dependent on financial engineers' application of machine learning algorithms. The dot-com bubble bursting occurred in the year 2000, followed by a large drop in the price of technology companies. Financial engineers created new risk management solutions as a response to the volatility and uncertainty of the market. The attacks on September 11 had a substantial influence on financial markets, which led financial engineers to build new models for managing the risks connected with terrorism and geopolitical instability. These models are intended to help mitigate the effects of the assaults. In 2002, lawmakers in the United States (US) enacted the "Sarbanes–Oxley Act", which increased the regulatory control of financial markets and enterprises.

Financial engineers put in extra hours to ensure that their work complied with the new standards and developed innovative strategies for risk management. Credit derivatives, including "credit default swaps", began to gain more and more popularity in 2003. Engineers in the financial sector developed new models for the pricing and Management of credit derivatives. The year 2004 saw the beginning of the rise of commodities trading as financial engineers developed new models for assessing commodity markets and managing the risks involved with commodity trading. This led to an increase in the popularity of commodities trading. The subprime mortgage crisis began to emerge in 2005, prompting financial engineers to design new models in 2006 to mitigate the dangers connected with "mortgage-backed securities" and other complex forms of financial instrumentation. This was a direct result of the subprime mortgage crisis. Creation of structured credit products Financial engineers came up with new "structured credit products", i.e. "collateralized debt obligations" (CDOs), which became popular among investors who were looking for greater yields. Other structured credit products included: Financial engineers who tried to design new risk management methods and address the systemic vulnerabilities that had contributed to the crisis. The US banking collapse and subprime mortgage crisis caused the global financial crisis in 2007. In 2009, increased regulation included the following: In reaction to the international economic meltdown, new legislation has been passed worldwide to improve financial stability and transparency. Financial engineers worked extra hours to ensure their work complied with the newly enacted standards and developed innovative risk management strategies in response to the heightened regulatory scrutiny. Generally, the period from

2000 to 2009 was defined by new financial products and technology, more regulatory scrutiny, and the necessity to manage the risks associated with volatile and uncertain market conditions (Ashton et al. 2012; Yan 2011).

In 2010, The development of blockchain technology and the Introduction of virtual currencies contributed to the ongoing progress of financial engineering (Zubaidi and Abdullah 2017). Modern control measures and mathematical models for assessing the state of the financial markets were also developed by financial experts. The sudden and dramatic collapse in the value of the US stock market, described as a "flash crash," occurred on May 6, 2010. Financial engineers put in a lot of hours to figure out what caused the catastrophe and devise innovative risk management measures to stop it from happening again.

In 2011, High-frequency trading continued to gain popularity (Kauffman et al. 2015), as financial engineers developed new algorithms and trading strategies to take advantage of high-speed trading technologies.

In 2012, the LIBOR scandal: The London Interbank Offered Rate (LIBOR) scandal broke out (Hou and Skeie 2014), revealing that banks manipulated the benchmark interest rate for their financial gain. Financial engineers innovated in measuring lending rates and global macroeconomic clarity.

In 2013, the Incorporation of Quantitative easing: Central banks worldwide launched different programs to remedy the economic crisis (Karadi and Nakov 2021). Financial engineers developed new models and techniques for managing the risks associated with quantitative easing and the resulting market volatility.

In 2014, Increase in regulatory oversight: Financial engineers continued to work closely with regulators to comply with new regulations (Johnston and Petacchi 2017), i.e. the "Dodd-Frank" Act in the US and the "Basel III" rules for banking supervision. They also developed new risk management techniques to address the increased regulatory scrutiny.

In 2015, Introduction of blockchain technology: The Introduction of blockchain technology and the creation of the first cryptocurrency, Bitcoin, sparked interest in financial engineering (Priyadarshini 2019). Financial engineers began exploring the potential of blockchain technology for creating new financial products and improving the efficiency and security of financial transactions.

In 2016, Focus on machine learning and big data: Financial engineers began to focus on the potential of machine learning and big data analytics (Qiu et al. 2016) for analyzing financial markets and developing trading strategies.

In 2017, the Rise of initial coin offerings (ICOs): ICOs, a type of crowdfunding that uses cryptocurrencies, became popular (Rhue 2018). Financial engineers worked to develop new models for valuing and analysing ICOs and managing the risks associated with investing in them.

In 2018–19, the Crypto market crash: The cryptocurrency market experienced a major crash (Hattori & Ishida 2021), leading financial engineers to develop new risk management strategies for investing in cryptocurrencies. They also worked to improve the transparency and regulation of the cryptocurrency market. In 2018 global financial crisis, governments rescued banks and other financial organizations. Financial engineers worked hard to develop new models and methods for managing the risks associated with government intervention in financial markets. These models and methods were used to manage the risks.

From 2010 to 2019, financial engineering was marked by new technological developments, increased regulatory oversight, and a focus on managing risk and volatility in financial markets.

Since it was first established, the discipline of financial engineering has undergone significant development, which can be seen in the production of novel financial instruments, the implementation of complex mathematical models, and the incorporation of cutting-edge technological systems and data analysis. These are just some of the advancements that have occurred (Koval et al. 2017). Financial engineering will inevitably advance in tandem with the progression of cutting-edge technology and the increasing complexity of the financial markets.

2.4 Theoretical foundations

Financial Engineering is a multidisciplinary field that combines principles from finance, mathematics, statistics, and economics to design and analyze financial products and strategies. When adding theoretical support to a manuscript on Financial Engineering, drawing upon relevant theories and models is essential. Study based on behavioral theory as proposed by (Khashanah and Alsulaiman 2016). Incorporating *Behavioural Finance Theories* can provide insights into investor behaviour biases, and irrational decision-making. It helps explain deviations from traditional finance theories and their implications for Financial Engineering instruments for complex financial products like derivatives and futures. By integrating *Behavioural Finance* theoretical underpinnings as per the literature (Lin et al. 2018; Matsumura and Kawamoto 2013), the manuscript will establish a strong foundation for understanding and analyzing financial engineering problems and contribute to the existing body of knowledge in the field financial market (Matsumura and Kawamoto 2013).

3 Recent research trends in financial engineering

In 2020, financial engineers still significantly influenced the markets thanks to their innovative risk management

and trading strategy optimization research and implementation (Nagar 2019). The need for risk management in financial markets was highlighted by financial engineers' role in developing strategies to mitigate the effects of the COVID-19 outbreak.

Between 2020 and 2022, financial engineering continued to develop and progress. The following are some of the most important recent developments include the COVID-19 pandemic impact, Sustainability and ESG investing, Digital currencies, Artificial intelligence, and machine learning, and Risk management and regulation (Daniali et al. 2021; Javaid et al. 2022).

Financial engineers have played a crucial role in designing risk control solutions to combat the impact of the COVID-19 epidemic on the financial system. Financial engineers, for instance, have created new models to evaluate epidemic risk and have been working on new financial products like pandemic bonds to mitigate the economic fallout of future epidemics (Debata et al. 2020).

To fulfill the rising demand for sustainable investing, financial engineers are hard at work inventing new financial products and models that consider environmental, social, and governance (ESG) factors (Javaid et al. 2022). Financial experts are also refining ways to evaluate businesses' environmental, social, and governance (ESG) performance and incorporate ESG considerations into investment choices (Yalmaev et al. 2021). Digital currencies dealing with Cryptocurrencies, like Bitcoin, have been increasingly popular, and this movement has been a major factor in financial engineering (Chakravaram et al. 2021). Financial engineers are now developing new blockchain-based financial products, such as stablecoins (digital currencies designed to retain a stable value). Financial sector engineers are still investigating AI and ML's potential (Goodell et al. 2021; Kim et al. 2020) for analyzing market data and creating profitable trading techniques. And they're also building new algorithms to spot emerging investment opportunities in response to the ever-evolving market. Financial engineers' research interests focus on risk management and regulation (Chen et al. 2022). To deal with new threats like cyber risk and climate change, they are creating new models and methods for risk management. They cooperate closely with authorities to improve the regulation and openness of financial markets and services (Souvannaseng 2022).

Financial engineering is a dynamic discipline where the landscape is always redrawn by the Introduction of new technology, products, and laws (Nagar 2019). Financial engineers will remain indispensable as the financial markets evolve and present new opportunities and problems.

4 Study methodology

Bibliometric Analysis (BA) techniques are employed for document analysis (Pritchard 1969). By analyzing bibliometric data, researchers have found that compiling knowledge on topics with extensive citation data is possible. Researchers follow a four-step process when conducting bibliometric reviews (Donthu et al. 2021). This process entails order: (1) Identifying the Nature and Extent of the Assessment; (2) determination of evaluation methods, (3) assembling and classifying research information; and (4) indicating the outcome.

By employing the bibliometric technique, the study focuses on the most referenced articles, researchers, universities, nations, most prestigious publications, and prevalent Themes. Finance researchers hope to deduce FE's innate brilliance through their work. Delimitations of the evaluated areas are large enough to encompass both special skills because of FE's pervasive use in the modern world community.

4.1 Fixing criteria for analysis

Researchers utilize many bibliometric approaches to map out the institutionalization of FE in finance studies. Also, you can manage corpora, which is a significant advantage (Goodell et al. 2021). Research outcomes patterns may be detected, new themes can be identified, and new visual representations of these developments can be made using BA. In this manner, we can simultaneously look forward to the past and the future (Bresciani et al. 2021). We utilize "co-citation analysis (CCA)", "bibliographic coupling" (BC), and "co-occurrence" techniques for the overall set of documents (Khan et al. 2021), all following the principles of the "citation". The CCA is a powerful tool for determining what information is crucial. However, BC does a good job explaining the fundamental ideas in the library's collection of works (Andersen 2021). It is possible to follow the development of a subject by analyzing co-occurrences.

4.2 Data extraction

Scopus is our ready repository since it contains the most comprehensive collection of scholarly articles on finance (Goodell et al. 2021). Our investigations employ many search terms, as evidenced by the current body of research (Alamad et al., 2021; Arnold et al., 2021). The methodology for collecting the final datasets for 343 studies is laid forth in Table 1. Scopus is a comprehensive and information-rich bibliometric database for quantitative science studies in the academic world (Baas et al. 2020; Kumar et al. 2023; Kumar et al. 2022). The Scopus database has recently been highly used compared to WOS and PubMed databases because of

Table 1 Prerequisites for Previous Re-checking language search Selection

Indicators for selecting "what to discard."	Reject	Accept
Filtering options		
Data Base: "Scopus"		
Access Date: 31/03/ 2023		
Terms used in a search: ("Financial Engineering and Finance, Financial Market, Technology adoption")		1135
Subject areas: "Accounting and Business, Management", "Economics", "Decision Science", "Social Science", and "Econometrics and Finance"	542	593
Search Period: 2007—2022	90	503
Language Verification: "English"	09	494
Manuscript Types: Articles, book chapters, books, conference papers, and reviews article	56	438
States of Publication: "Final" and "Accepted Article"		438
Material assessment: Incorporate papers if "Titles, abstracts, and keywords" fit the research scope of FE	95	343

Note: Table illustrates Scopus's current 343-article accumulation. Compiled by- The Authors

its worldwide access coverage and multidisciplinary research platform (Al-Khoury et al. 2022; AlRyalat et al. 2019). So, based on the prior study's recommendations (Baas et al. 2020; Kumar et al. 2022), the present study uses the Scopus database to conduct a bibliometric analysis on the Theme of FE. Data on the original research papers has been integrated with bibliographic and bibliometric information since it was extracted from the Scopus database using programs like R Studio and VOS-Viewer (Goodell et al. 2021).

Research on financial engineering began in the mid-1970s, but only about 25 documents were published between 1970 and 2006. Notable articles, however, appeared between 2007 (343 publications) and 2022. Since then, the authors have advocated for a bibliometric study of Research Trend's output throughout the preceding 15 years, starting in 2007. Therefore, the risk of making an unwarranted claim increases when such records are converted without being cleaned. To clear it up, we check the data's references. The extension, visualization, and comprehension of bibliographic data are all facilitated by using this route (Donthu et al. 2021). The authors used a filtration procedure that considered various keywords in light of the existing literature and the reviewers' feedback. We searched "Financial Engineering" and "Finance" for the above-filtered data.

5 Results and analysis of the study

5.1 Achievements in research and scientific output

5.1.1 Findings in financial engineering research

The annual article count is plotted in the FE research and innovation phase. (Fig. 1) shows that FE in the financial sector has been around since the 1970s. This is the first research done on FE (Woodcock and Barrett 1970) published by Scopus was "Economic indicators of the impact of air pollution control: Gray iron foundries: A case study". This analysis only considers works published in the last fifteen years (2007 to 2022). It is clear evidence from the Table 1, 2023 comes in first place with 35 publications, and 2022 with 31 s highest publications followed by 2012 with 28 publications, 2017 with 24, and 2015 with 23 articles. The emergence of the fourth industrial revolution can partly be attributed to the recent explosion of interest in these types of financial studies. Thirty-five articles on FE in the financial market were published in 2022, up from one in 2021 (31 articles were published). Which is 113 percent of the number of articles published in 2021.

Fig. 1 Articles published tendencies in FE research

5.1.2 Prominent researchers, institutions & nations engaged in fe study.

This study highlights author's names, journals, affiliations, and countries of the top authors contributing to FE research in finance. Regarding FE research in finance, Duffy D.J.& Cressy R emerges as the most impressive and prominent author, accompanied by 111 citations, and Al Janabi M.A.M. with 85 citations. Regarding the number of articles published annually, Al Janabi M.A.M. is currently the most prolific author, having thirteen publications. For organizations, both the "University of Birmingham Business School" (United Kingdom) & "The University of Bologna" (Italy) has more citations, with 696 and 319, respectively. Three publications from United Arab Emirates University rank it as the most productive organization in terms of research production. The United Kingdom (total research publication 83) and the United States (total research production 32) are two prominent countries in the field of research concerning FE. In the research world, India is also a major contributor (9 academic papers). A record number of citations was recorded in 2013.

5.1.3 Leading journals in the area of FE.

The most acclaimed journals in the field of FE are included in this list (Table 2). With the highest citation of 159, 71, and 47 citations each, "Quantitative Finance", "Journal of Banking and Finance", & "Accounting Horizons" are the three most important journals in financial research and theory. There has been a recent uptick in the amount of work published in this field, as shown by the graph of publication productivity over time.

When comparing the productivity of publications over different periods, it is possible to see that there has been a recent increase in publication activity on the subject of this review. This is extensively documented in "quantitative finance" & the "Journal of Banking and Finance". The Australian Business Deans Council (ABDC)-2022 Journal Top-notch List, for example, ranks approximately 63 percent are published in the top-rated journal in the "A", "B", and "C " categories. These are among the most notable journals for emphasizing financial engineering research in recent times. As publications in prestigious journals stimulate scholarly interest (Baker et al. 2021), these trends indicate that

Table 2 Prominent Journals in FE Research

Journal Abbreviation	TC	FIN	TP	ABDC Indexing	Publishers	2007–2011	2012–2016	2017–2021	Up to 2022
QF	159	X	11	A	*T&F*	4	6	1	
JOBF	71	X	5		*ELS*	3		1	1
AH	47	X	2	A	*AAA*	1	1		
FI	28	X	3		*SPN*			2	1
AFR	23	X	3	C	*EGP*		3		
JOD	17	X	5		*PMR*	2		2	1
IJORAM	15	X	2	C	*IEL*	2			
JOKAU	17		6		*KAUSPC*	5		1	
MJOSS	17		4		*MCSER*		3	1	
ORL	13		2	A	*ELS*	1		1	
JOAM	11	X	2	B	*SIP*	1	1		
BTP	10	X	3		*VGTU*		1	1	1
JOCMS	9	X	2	B	*WBP*			2	
FETEP	7	X	10		*WBP*		8	2	
AEL	5	X	2	B	*DG*			2	
EE	4		2	B	*KUT*			2	
SEF	3	X	2	B	*EGP*	1			1
APFM	2	X	3	C	*SIP*	1	1	1	
FRL	2	X	2	A	*ELS*			2	

Note(s): abbreviations are:- QF(Quantitative Finance), JOBF(Jornal of Banking and Finance), AH(Accounting Horizons), FI(Financial Innovation), AFR(Agricultural Finance Review), JOD(Journal of Derivatives), IJORM(International Journal of Risk Assessment and Management), JOKAU(Journal of King Abdulaziz University, Islamic Economics), MJOSS(Mediterranean Journal of Social Science), ORL(Operations Research Letters), JOAM(Journal of Asset Management), BTP(Business: Theory and Practice), JOCMS(Journal of Common Market Studies), FETEP(Financial Engineering: The Evolution of a Profession), AEL(Accounting Economics and Law), EE(Engineering Economics), SEF(Studies in Economics and Finance), APFM(Asia–Pacific Financial Markets), FRL(Finance Research Letters). The table's ranking are determined based on the total citation received by individual journals. *Compiled by- The Authors*

research in this area of FE in finance will become increasingly relevant. (Table 2) Of the selected highly cited 19 journal publications, 79% come under core finance publication (15 nos), and the rest, 21%, are only included in the non-finance publication journal publications. We see a significant difference between finance and non-finance publications (Goodell et al. 2021). This table also featured a selection of well-regarded books and journals. The data shows that Elsevier (ELS- Elsevier -03), Emerald (EGP- Emerald Group Publishing), Springer (SIP- Springer International Publishing), and Wiley (WBP- Wiley-Blackwell Publishing) are the top five publishing houses in the world of engineering in the financial sector or FE and related disciplines.

5.1.4 Finest journal articles in FE research

FE research articles that have received the most citations. The paper by Duffy (2013) is perhaps the most cited article in Scopus (158) and, thus, the most significant and influential. This is evident because it has been cited many times, i.e. (111). The next piece of notable FE research that cites this one is Sheng (2009). Is (85). The second most-cited article in recent years is from 2017 Oster Rieder & Lorenz (2017) (58) times. Finite Difference Strategies in Financial Engineering: A Partial Differential Equation Approach" Duffy (2013) is the most-cited paper in the field. Different types of derivative products, such as "plain European and American options," "multi-asset options," and "interest rate options," were part of Financial engineering's users-centric paradigm used "partial differential equations".

An article highlighting the role of PE in achieving strategic advantage. This article suggests private equity firms rely less on managerial incentives to increase performance.

Last, the most comprehensive article cited (Osterrieder and Lorenz 2017), which focuses on "Bitcoin statistical risk assessment" and extreme tail behavior, has provided the newest investment avenue. Arbitrage and volatility (Gatheral and Jacquier 2014) research dominates other FE activities, "Assets Pricing" (Buchanan 2019), Evaluating and controlling threats during crises, etc.

5.1.5 Important publications and articles on FE

The Scopus's highest publications on "FE research was employed" reveal the FE study's biggest importance in present times. Important articles on specialized or non-financial issues that escaped our initial search may now be brought to light through this analysis. The most frequently referenced articles are ranked by both the number of local citations (LC) and the number of global citations (GC) to those publications (Table 3). When run on R-Biblioshiny studio's platform, the table below displays the results of a search on a database using the Scopus database. (Xie et al. 2020) To conduct pertinent analyses via an engaging web interface, Biblioshiny is the greatest scientific mapping analysis tool available. The amount of time and effort required to submit data is greatly diminished with Biblioshiny.

Local citations reveal the frequency with which a given research work has been cited by other scholars, as reported by FE research in finance. There were multiple references to global sources. Articles in the realm of finance that reference

Table 3 Notable references on financial engineering

LC	Authors	Thematic title	GC
5	(Al Janabi 2009)	"Commodity RM and Market Settings"	17
4	(Breuer & Perst 2007)	"Retail banking and FEP"	49
4	(Al Janabi 2013)	"Optimal Structure and Trading Position"	29
3	(Al Janabi 2012)	"Asset allocation and modeling"	18
2	(Kalvet et al. 2012)	"FE instruments and policy decision"	11
2	(Al Janabi 2011a)	"Equity Allocations and portfolio"	7
2	(Al Janabi 2008)	"Risk analysis and control"	9
2	(Al Janabi 2007)	"ETRM and stock exchange"	7
1	(De Grauwe & Ji 2019)	"FE Sustainability"	9
1	(Dye et al. 2015)	"FE and AS"	29
1	(Assa 2015)	"FE and Insurance"	4
1	(Dąbrowski 2015)	"FI for Urban Development"	13
1	(Turvey et al. 2014)	"FE and farm problem"	8
1	(Gatheral & Jacquier 2014)	"Arbitrage and Volatility"	58
1	(Fagnan et al. 2013)	"FE and Cancer"	27
1	(Iqbal 2012)	"FE and Islamic Finance"	2
1	(Al Janabi 2011b)	"Trading Risk and Market Prediction"	3

Compiled by- The Authors

Financial Engineering often reference topics that are unrelated to the discipline. A few main references keep coming up (Al Janabi 2009) and (Breuer and Perst 2007), being tied for the most number of citations, four.

This table presents a lot of interesting facts, one of which is the fact that FE plays an important role in the examination of non-financial domains (Fagnan et al. 2013) "Can cancer be cured with the use of financial engineering?" (GC-27 & LC-1). It elucidates FE's health-related research and contribution, which has far-reaching societal implications. This research describes how FE aids in recovery from cancer. One of the many global issues is cancer that modern civilization faces and it is one of the few problems that can be solved by a modern society only via the sustained collaboration of thousands of highly competent, motivated, and autonomous individuals over many years. Methods of financial engineering such as portfolio theory and securitization help to make complex collaborations easier to accomplish by offering the necessary financial incentives to all the relevant parties. Given the scope of the issues that must be addressed, we cannot rely exclusively on altruism and charity giving to respond to these difficulties. Although these motivations are vital, we cannot rely on them alone. By organizing funding for biomedical research in the form of an obligation backed by research, it is possible to distribute rewards to reduce disease burden among a significantly larger group of stakeholders. Because of this, much more resources can be gathered to tackle problems of this nature, which, in turn, will entice leading specialists to join the endeavor, inspiring even more trust among investors, and so forth.

A "virtuous cycle" of this kind provides organizations driven primarily by altruism with a potent new instrument for achieving social impact. In addition to these sources, the following citation focuses on "FE & the arms race among accountancy standard setters & preparers," which is taken from the research conducted by Dye et al. (2015) and has 29 references. FE in stock market volatile measure and a threat assessment of securities are the next key topics of GC research Al Janabi, (2009, 2011a, 2012, 2008), according to (Alwi et al. 2021). Recent research in the field of Financial Engineering has been executed by (De Grauwe & Ji 2019) on the topic of "Making the Eurozone Permanent by Financial Engineering or Political Union?" with the authors examining both options (LC-1 & GC-9). Policymakers have felt the majority of its impact. It denotes, to begin, the Introduction. The financial situation in the Eurozone can be made more stable with the help of properly created financial assets. Because political approaches, such as political integration, have shown to be unsuccessful, the policymakers in the Eurozone favor this idea.

(Al Janabi 2009) The paper focuses on managing commodity price risk demands knowledge of the market and the flexibility to adapt solutions to meet the unique requirements of each business. (Breuer and Perst 2007), Intra- and interlinking, as shown by Global Citation (GC)-49, depending on the subject relevance & high local citation(LC) counts (4 total) related to "Retail banking and behavioral financial engineering": The case of structured products". The importance of research into Discount reverse convertibles and reverse convertible bonds should be considered by rational investors when evaluating structured products from their perspective. Future research in these above top cited articles can be explored further.

5.2 The organization and analysis of research in the FE sector using clustering

5.2.1 A topical grouping derived from citation similarities in financial engineering research

In this analysis, we traced the citation trails of numerous financial engineering studies. In contrast to co-citation analysis, which concentrates on the most highly cited papers, this method prioritizes papers with a middle-range Co-citation count. Co-citation analysis examines highly cited papers (Donthu et al. 2021; Goodell et al. 2021). "Bibliographic Coupling," or "BC," is the process of employing references to elaborate on previously established ideas (Goodell et al. 2021). It includes knowledge that is fundamental and specialized, as well as knowledge that is up to date. In this manner, it identifies works that, because they are more recent, may be overlooked in co-citation analyses (Khan et al. 2021). Using bibliographic coupling, we identified seven topical areas that contribute to an overall understanding of FE research in the finance market.

Each cluster (CL) is given a thorough analysis concerning the originality of its research in the realm of FE. According to the Scopus database, CL-1 is comprised of 78 papers in the fields of FE and Financial Markets which have been peer-reviewed more than two hundred and forty times in the last fifteen years. (Duffy 2013), (Kou 2007) (Fernandez 2011) is the most-cited study in the field, with 158, 49, and 34 references, respectively.

(Duffy 2013) presented the idea that the study of pricing derivatives experimenting with FE with quantitative finance (QF) is a growing study area. There has been a significant increase in the number of models that may be utilized in the simulation of financial products, such as "simple and exotic options," "interest rate derivatives," and "real options."

(Kou 2007) In financial engineering, jump-diffusion models frequently value assets whose prices tend to spike or jump suddenly. Such models have been helpful, although they are not without difficulties.

According to the Scopus database, CL-2 contains 47 articles in "Finance and Risk Management" peer-reviewed 241 times over the past fifteen years. Risk management and It

Heighlits finances are inseparable partners for the financially astute. Risk management is concerned with the identification, assessment, and Management of risks that could affect the financial performance of an organization, while finance is concerned with the allocation of resources and valuation of financial instruments. To effectively manage risks, one must have an in-depth familiarity with the business's operations and financial situation, both of which are crucial to the achievement of financial goals (Gatti 2008; Kouvelis et al. 2011; Sheng 2009) are published studies that have received the most citations, with a total of 85, 58, and 33 respectively.

(Sheng 2009) Discover about "unrestrained finance" from industry experts. He was familiar with the Asian crisis of the late 1990s and the global financial crisis of 2008–2009 due to his experience as an Asian regulator. This research suggests that our current crisis management practices and institutions need updating in light of the increasing globalization of the financial sector. The current framework of financial laws and regulations is inadequate to deal with a worldwide emergency. (Gatti 2008) Project finance for large projects is growing fast. Project finance blends legal and contractual skills with financial engineering to create funding solutions. (Kouvelis et al. 2011).

"Emerging Market & Financial Risk Management" and "Option Pricing & Financial Mathematics" have three and seven research publications in the CL-3 and CL-4 categories, respectively. According to Scopus, each of the ten research papers has been cited ten times in the preceding 15 years.

(Al Janabi 2014) and (Chan and Wong 2013) are the top CL-3 published studies referenced (1 2 times respectively). (Sen et al., 2017), (Sakuma & Yamada, 2014), (J. R. Buchanan, 2012), and (Raymond H. Chan et al., 2019) are those CL-4 research articles that have been cited the most (3,1,2 &1 times respectively).

Research on The Credit Crunch and the Credit default swaps Monetary Crisis's Impact on International Equity Risk Analysis is the primary emphasis of CL-3. An Evaluation of the Impacts of the Subprime Financial Crisis & credit risk on Developing Economies (Al Janabi 2014) as well as notable risk management modeling approaches (Chan and Wong 2013).

Next, CL-5, 6 & 7 address "Economics & Innovation," "Global Financial Crisis & Investment," and "Financial Crisis & Financial Market," respectively. The associated published work includes 15 CL-5 nos., and three famous scholars (Berlyavskiy et al. 2018), (Ajupov et al. 2014), (Carayannis and Papadopoulos 2011) citing (2, 10, 08 respectively). At the same time, CL-6 no. of the related published article has 13 in nos. And among the two prominent researchers are (Kayed and Hassan 2011) (Maringer and Ramtohul 2012), with citations of having (54 and 17, respectively). In contrast, CL-7 no. of the related published article has 11 nos. and among four prominent researchers are (Matiş et al. 2009), (Al Janabi 2014), (Quinn 2017), (Schmidt 2011) with citations of having (2, 01, 25,09 respectively).

Financial engineering was also studied concerning the financial market, but the sociologist's view study had never been taken. (Jena et al. 2023; Quinn 2017) attempted to study FE roles in financial institutions and national financial markets. It is well known that financial institutions and national financial markets have a strong relationship, but sociologists have overlooked the importance of national budgets in establishing that relationship. This article addresses the gap using an American historical case study. Implications are drawn for fiscal sociology, the sociology of finance, and the interaction between fiscal and financial systems over time. This kind the topic will be an eye-opener in the field of FE.

According to a co-citation analysis, three main topic groups are interconnected, as mentioned earlier. Clusters 1–3 cover topics like emerging financial markets and risk management; Clusters 6–7 focus on Crises addressed through adopting technologies like IOT and ML; and Clusters 4–5 discuss topics like Option pricing and financial mathematics with innovations. The aforementioned overarching Theme provides the narrative framework for FE studies.

5.2.2 *Co-occurrence analysis as a tool for identifying themes FE research analyses*

These findings are based on a co-citation study and bibliographic coupling. In this subsection, we utilize co-occurrence analysis to look at the development of FE studies in the financial sector. The co-occurrence and all keywords are analyzed (Li and Xu 2021). This type of terminology, viewed through the lens of three times the typical occurrence of a keyword during the specified period, helps to highlight the development of a central theme in the reviews we have compiled (Li and Xu 2021).

The progression of this topic over time is depicted in Figs. 2, 3 and 4. The topics (themes) are publishing year (PY), an indicator of current interest shown below in figures.

From PY 2007 to 2022, as shown in Figs. 2, 3 and 4, the number of researchers engaged in FE expanded dramatically. Research in (Fig. 2) covers the year PY 2007–2012. "Financial risk management, developing markets, portfolio management, liquidity risk", and the 2008 "financial crisis" are all areas where FE research has shown promise (Bottle green nodes). Intriguing areas of study include "identified, including value at risk, risk management, investments, and financial risk" (Light blue nodes). Potential applications are outlined in the areas of "financial mathematics", "economics", "finance", "financial engineering", "commerce", "pricing models", "cost consideration", and" financial engineering"(Orange nodes).

From PY 2012 to PY 2017, the data presented in (Fig. Research in the field of finance that emphasizes "portfolio

Fig. 2 Presents significant topics from 2007 to 12

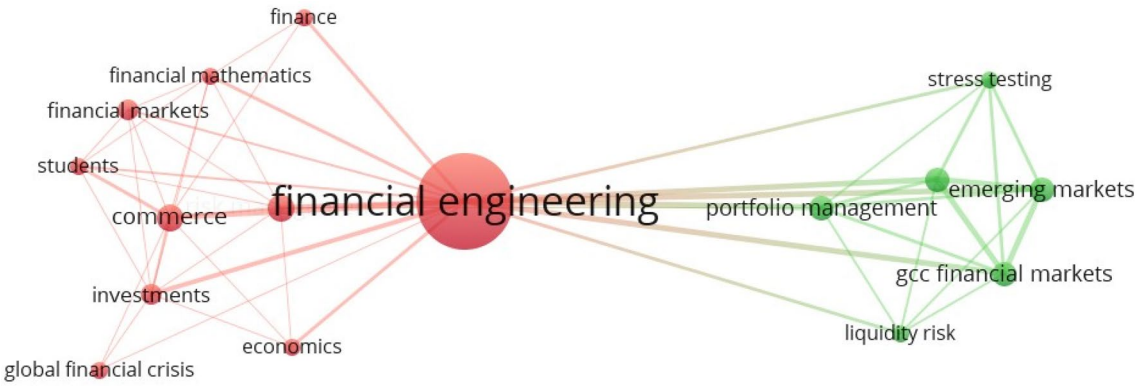

Fig. 3 Significant topics from 2012 to 2017

management, emerging markets, the Gulf Cooperation Council" (GCC) "financial market, financial risk management, stress testing, and the liquidity ratio" has shown encouraging results (Bottle green nodes). The fields of "financial engineering, risk management, commerce, investments, financial mathematics, the financial market, economics, finance, and the global financial crisis" are recognized as potential growth areas (Orange nodes).

Time frames for analysis are shown in (Fig. 4) as PY 2017–2022. "Finance, Risk Management, Economic and Social Effects, and Risk Assessment" are considered interesting areas of FE research in finance (Bottle green nodes). We see potential in portfolio allocation (Light blue nodes).

Financial innovations, option pricing, and other branches of FE" all show signs of "future growth" (Orange nodes). This article highlights decision-making as a promising subject for future research (Yellow nodes).

5.2.3 The integration of FE study themes/approaches

Researchers analyse the relationship between study themes and methodologies in FE research in the combined area of bibliographic and co-occurrence analysis. Table 4 displays a matrix that compares the most researched methods in finance and FE with the most researched issues in these fields. The table's columns reflect the information presented in the preceding sections.

Table 4 shows that the Black–Scholes option pricing model has become increasingly dependent on the tools of FE (Edeki et al. 2020). A recent study (Edeki et al. 2020) places close attention to "Closed-form solutions of the time-fractional conventional Black–Scholes model for valuation models using he-separation of variable approach.".

Financial risk can be reduced for asset pricing with the use of FE. Similarly, the importance of (Tapiero 2011) asset

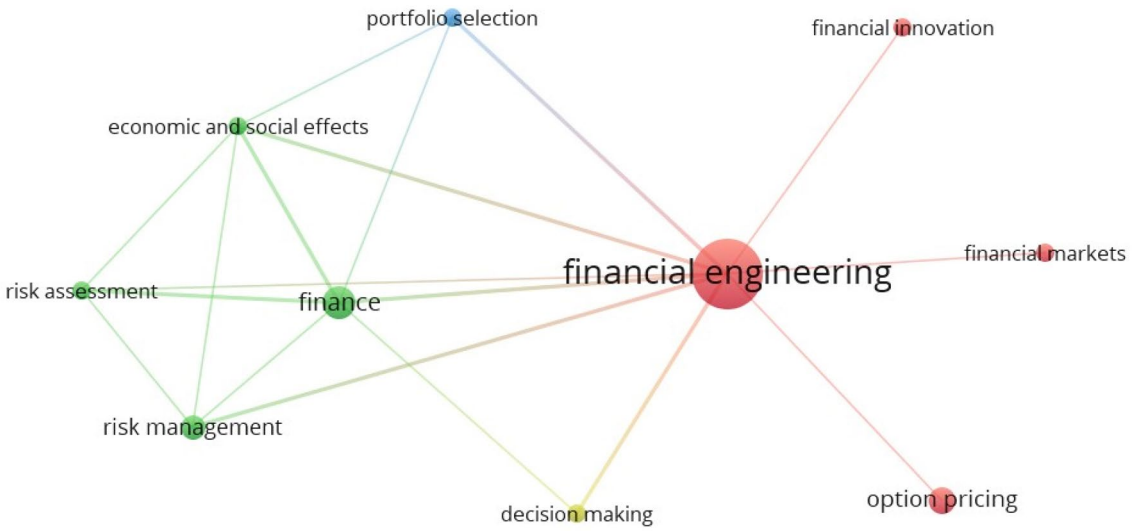

Fig. 4 Significant topics from 17 to 22

Table 4 Various techniques in FE studies

Thematic topics	TP	TC	RA	DA	SA	AP	OP	VE
Barrier options	9	17	1	1		2	3	2
Conditional value-at-risk	6	56	1	2		1	1	1
Derivatives	42	384	5		1	26	3	4
Economics	29	144	2	1	3	6	15	2
F crisis	28	208	7		4	6	8	
F markets	69	368	11			19	34	4
F mathematics	8	34				2	5	
Financial risk	11	66	5		1	1	1	3
FRM	5	13	4				1	
Global financial crisis	8	110	4			4		
Implied volatility	9	67		1		2	3	2
Innovation	27	53	6				12	7
Investment	63	423	13		7	12	25	6
Optimization	29	154	4		3	1	12	9
Risk	134	939	30	4	7	29	32	31

Note: TP—"Total Publications", TC—"Total Citations", RA- "Risk Analysis", DA—"Decision Analysis", SA—"Sensitivity Analysis", AP – "Asset Pricing", OP- "Option Pricing", VE- "Value Engineering". *Complied by The Authors*

pricing explains the Value, Measurement, and Markets of Risk in Financial Asset Pricing. Unconcerned with how it affects others, the use of FE for RA has recently skyrocketed in popularity. Two of RA's functions are "pricing and hedging". "Pricing" can be used to estimate the worth of a financial instrument.

5.3 Suggested theme of research

Prior analyses have been condensed and given in this format for your convenience. Because of this, we have high hopes that our findings and retrospective will contribute to the meaningful advancement of FE research in finance. In the next paragraphs, we'll discuss a few concepts for future investigations.

5.3.1 Option and asset pricing FE

There has been a rise in the importance of the study of financial engineering, which is the application of mathematical and quantitative methodologies to financial problems.

Exotic option pricing and hedging tactics are two examples where researchers have applied option pricing models. This is why numerous approaches, such as Monte Carlo simulation and numerical methods, have been developed for valuing and analyzing options in varied contexts.

Improvements in modeling the connection between risk and return have been a major focus of asset pricing research. For instance, the CAPM has been frequently employed to estimate the return on assets based on their beta, but its validity and applicability in practice have been the subject of continuous discussion (Edeki et al. 2020). At times exploration into additional models, such as factor models and machine learning methods, may be able to depict the complexities of the financial markets more accurately. These models are developed to produce more precise estimates of asset prices and returns by better capturing the sources of risk and reward in financial markets. There has been a general improvement in our understanding of financial markets and new, more precise tools for monitoring and controlling financial risk, thanks to the studies conducted in financial engineering on option and asset pricing.

5.3.2 Modelling operational risk in engineering through machine learning

The modeling of operational risk using machine learning is another approach that has been an emerging area of study (Leo et al. 2019). The term "operational risk" describes the potential for financial loss resulting from factors within an organization, such as its systems and personnel. Machine learning methods can analyze operational process data to reveal patterns and relationships indicative of operational risk occurrences. Next, this data can be utilized to create models for detecting and lowering operational risk (Pena et al. 2021). Financial Engineering's risk modeling has benefited greatly from the application of machine learning. It paves the way for more precise and complex models that may be utilized for risk management in various financial environments.

5.3.3 Financial engineering and Internet of Things (IoT)

IoT is having an impact in the area of investment management. The IoT can provide data on various economic and market indicators, such as consumer sentiment, industrial production, and transportation volumes. This data can be analyzed using machine learning and other techniques to develop more accurate asset pricing models and identify investment opportunities. The IoT is also having an impact on the development of new financial products and services. For example, IoT devices and sensors can enable new types of insurance products based on real-time data (Ding et al. 2021), such as pay-as-you-drive car insurance or usage-based insurance for home appliances. The convergence of financial engineering and the Internet of Things creates new prospects for innovation and expansion in the financial industry (Jena et al. 2023). Despite this, it is essential to be aware that implementing these technologies is not without its share of dangers and difficulties. Among these are concerns about protecting personal information and privacy, as well as the possibility of systemic risks and market disruptions. To effectively address these difficulties and guarantee that the benefits of new technologies are achieved in a responsible and environmentally conscious manner, it will be essential for policymakers and industry stakeholders to collaborate (Wu et al. 2021).

6 Contribution of the study & conclusions

6.1 Theoretical contributions of the research

Incorporating insights from psychology and cognitive biases into conventional financial models is one of behavioral finance theory's theoretical contributions to financial engineering research in financial markets. The hope is that these additions will help us better comprehend investment habits, market dynamics, and the valuation of financial assets. Insights into risk perception and decision-making biases are provided by behavioral finance theory, which advances the subject of risk management. The central topic of the theoretical contributions is how risk-taking, risk appeal and risk evaluation are affected by one's mental state. This aids in constructing risk management frameworks that factor in behavioral biases, guaranteeing more efficient risk mitigation measures.

6.2 Practical contributions of the research

Financial engineering assists businesses and clients in improving their financial performance. Using quantitative approaches and financial models, practitioners can optimize operations, increase profitability, manage costs, and minimize inefficiencies. The study presents four advanced techniques and methods adopted by the industry as below.

1. *Machine learning (ML) and artificial intelligence (AI) in FE*: Financial engineering is one area where ML and AI have recently gained popularity. Predictive modeling, algorithmic trading, risk assessment, and fraud detection are just some of the applications of these technologies.
2. *Blockchain technology (BT) in FE*: When applied to financial engineering, BT could have far-reaching effects, particularly in trade resolution, clearing and settlement processes, and smart contracts. Financial engineers are increasingly turning to distributed ledger

technology to streamline processes, boost openness, and lower transaction costs.

3. *High-frequency trading (HFT) in FE:* High-frequency trading (HFT) is widely used in financial markets because it helps traders profit from minute price differences and market inefficiencies. Financial engineers are essential to the success of HFT strategies due to their efforts in creating complex algorithms and risk management frameworks.
4. *Financial engineers in Risk Management and derivatives in FE*: Risk management and the creation of financial derivatives are two areas where FE actively pursues innovation. Refined and coupled with machine learning approaches, advanced risk models like value-at-risk (VaR) and conditional value-at-risk (CVaR) increase accuracy and reliability. In addition, new derivatives are being developed to address specific risks, such as weather derivatives and disaster bonds.

An exhaustive survey of the literature on financial engineering in emerging nations for 2007–2022 is presented in "A Bibliographic Assessment of Financial Engineering in the Emerging Financial Market from 2007–2022." Several scholarly articles were analyzed to understand better financial engineering methods and their application in developing financial markets. The analysis identified emerging market obstacles and opportunities, including legislative frameworks, market structures, economic conditions, and cultural issues. It has illuminated the changing role of financial engineering in these markets and how practitioners and scholars have handled financial product and risk management difficulties. Focusing on the financial sector's biggest issues helps researchers and practitioners meet consumers' and investors' needs in a dynamic market.

To answer RQ-1, researchers should systematically search databases such as Scopus for financial engineering keywords. Sorting the search results by citations will yield the most referenced articles. Using terms related to financial engineering, a search on databases such as Scopus can identify which researchers have made the most significant contributions to financial engineering. An additional new contribution to RQ-2 is the identification and study of the collaboration networks of the most significant researchers in the field of financial engineering. By examining the authors' co-authorship patterns, we can learn more about the intellectual communities and research clusters that have emerged within the field and uncover new areas for research and collaboration. This can lead to greater cross-disciplinary effort, which can lead to the development of creative ways to difficult monetary problems. A potential third novel addition to RQ-3 is the identification of newly-emerging publications or venues that are gaining prominence in financial engineering. As the third innovative component, authors can learn more about the changing nature of research in the field and uncover prospects for collaboration and interdisciplinary study if we can track down the most recent and greatest publications on the issue and the final response to RQ-3, it would be to make a fresh contribution by not only identifying the most common themes in financial engineering research but also analyzing how these themes have changed, identifying emerging research areas, and maybe breaking new ground. One technique could be conducting a thorough financial engineering literature review on essential books and publications. This might be used with interviews and surveys of subject matter experts to uncover new and potential research areas.

During the 2008 financial crisis, several flaws in financial engineering were found, stressing the need for new research and solutions to improve risk management and prevent future disasters. Financial engineers are frequently faced with complex problems such as:

The market should have strong risk management approaches: The financial crisis demonstrated that traditional risk management tactics, such as value-at-risk models, were insufficient for capturing the complexities of risk in the financial services industry. New approaches and models will be necessary to more precisely reflect the interaction of market variables and the potential for systemic risk.

The market should have greater transparency and accountability: Collateralized debt obligations and credit default swaps are just two examples of complex financial arrangements that make it difficult for investors to gauge the possible risk. Increased transparency and accountability are required to protect investors' ability to make informed decisions and to prevent the emergence of unregulated, high-risk financial products.

The market should have more effective regulation: The financial crisis exposed flaws in the regulatory structure, particularly in the monitoring of sophisticated financial products and the behavior of financial institutions. New laws will be required to prevent financial institutions from taking undue risks and to hold them accountable for their actions.

6.3 Limitations and future scope

The current study is limited to the filtering parameters, namely Data Base: "Scopus," Search Period: 2007—2022, and it is only valid until March 31, 2023. All of the resources and articles retrieved for this study are restricted to financial market connections. Not all papers are cited immediately, resulting in insufficient citation statistics is another limiting factor, which leads to bias the assessment of research impact and may not fully reflect the influence of certain works or researchers.

Research in the future can build on this body of work on developing novel frameworks and methods ideally suited to

the constraints and characteristics of emerging financial markets. This may imply keeping pace with novel approaches to risk management, pricing procedures, investment strategies, or rules for the design of financial products tailored to these markets' specifics. Empirical research, the creation of new approaches, and the investigation of novel applications of financial engineering techniques in the context of emerging economies are all viable options for future study that could help fill in the gaps identified based on themes wise and cluster-wise.

In light of challenges (as mentioned in Sect. 6.1), some of the growing areas of study interest in financial engineering may concentrate on:

Innovation in risk management in FE: There is a need for financial engineers to provide new models and methods that can more accurately reflect the nuances of systemic risk and other complex risks inherent to financial products.

Adopting greater openness and honesty in FE: Financial engineers will need to develop new norms for transparency and disclosure, especially concerning sophisticated financial products, in collaboration with regulators and industry partners.

Improving Controls and Regulations in FE: To curb reckless lending practices and ensure that financial institutions are held accountable for their activities, financial engineers must collaborate with regulators to create new rules and monitoring systems.

Overall, financial engineering will play a significant role in the finance system, but new research and solutions will be needed to solve the issues that were exposed by the 2008 financial crisis.

Funding The present manuscript declares that no funding was received in the devlopment of this research work.

Declarations

Conflict of interest The authors have no relevant financial or non-financial interests to disclose. The authors have no conflicts of interest to declare relevant to this article's content.

Human Participants and Animals This is a review article. The Research Ethics Committee has confirmed that no ethical approval is required.

Informed consent All the author's consent was obtained and the corresponding authors will be a single point of contact.

References

Abad-Segura E, González-Zamar MD, López-Meneses E, Vázquez-Cano E (2020) Financial technology: review of trends, approaches, and management. Mathematics 8(6):1–36. https://doi.org/10.3390/math8060951

Ajupov A, Kurilov K, Kurilova A, Artamonov A (2014) Reconomic bases of formation and development of financial engineering in financial innovation. Mediterranean J Soc Sci 5(24):300–306. https://doi.org/10.5901/mjss.2014.v5n24p

Al Janabi MAM (2007) Equity trading risk management: the case of casablanca stock exchange. Int J Risk Assess Manage 7(4):535. https://doi.org/10.1504/IJRAM.2007.012743

Al Janabi MAM (2008) A practical approach to market risk analysis and control: empirical test of the Mexican foreign exchange and stock markets. Int J Risk Assess Manage 9(1/2):70. https://doi.org/10.1504/IJRAM.2008.019314

Al Janabi MAM (2009) Commodity price risk management: valuation of large trading portfolios under adverse and illiquid market settings. J Der Hedge Funds 15(1):15–50. https://doi.org/10.1057/jdhf.2008.27

Al Janabi MAM (2011a) Dynamic equity asset allocation with liquidity-adjusted market risk criterion: Appraisal of efficient and coherent portfolios. J Asset Manag 12(6):378–394. https://doi.org/10.1057/jam.2010.28

Al Janabi MAM (2011b) Modeling coherent trading risk parameters under illiquid market perspective. Stud Econ Financ 28(4):301–320. https://doi.org/10.1108/10867371111171555

Al Janabi MAM (2012) Optimal commodity asset allocation with a coherent market risk modeling. Rev Financ Econ 21(3):131–140. https://doi.org/10.1016/j.rfe.2012.06.007

Al Janabi MAM (2013) Optimal and coherent economic-capital structures: evidence from long and short-sales trading positions under illiquid market perspectives. Ann Oper Res 205(1):109–139. https://doi.org/10.1007/s10479-012-1096-3

Al Janabi MAM (2014) Tactical risk analysis in emerging markets in the wake of the credit crunch and ensuing sub-prime financial crisis. In: Emerging markets and the global economy. Elsevier, Newyork, pp 413–446. https://doi.org/10.1016/C2012-0-03535-1

Al-Khoury A, Hussein SA, Abdulwhab M, Aljuboori ZM, Haddad H, Ali MA, Abed IA, Flayyih HH (2022) Intellectual capital history and trends: a bibliometric analysis using scopus database. Sustainability 14(18):11615. https://doi.org/10.3390/su141811615

AlRyalat SAS, Malkawi LW, Momani SM (2019) Comparing bibliometric analysis using pubmed, scopus, and web of science databases. J Vis Exp. https://doi.org/10.3791/58494

Alshubiri F, Elheddad M, Doytch N (2020) The impact of fish production on marine trade balance and foreign direct investment: an empirical study of the GCC economies. Marine Policy 116:103660. https://doi.org/10.1016/j.marpol.2019.103660

Alwi S, Malan INB, Munirah R, Yusof SH, Aslam SNAM (2021) Analyzing systematic risks associated with financial engineering commodities. Rev Int Geograph Edu 11(7):612–618

Andersen N (2021) Mapping the expatriate literature: a bibliometric review of the field from 1998 to 2017 and identification of current research fronts. Int J Human Resour Manage 32(22):4687–4724. https://doi.org/10.1080/09585192.2019.1661267

Ashton P, Doussard M, Weber R (2012) The financial engineering of infrastructure privatization. J Am Plann Assoc 78(3):300–312. https://doi.org/10.1080/01944363.2012.715540

Assa H (2015) A financial engineering approach to pricing agricultural insurances. Agric Financ Rev 75(1):63–76. https://doi.org/10.1108/AFR-12-2014-0041

Baas J, Schotten M, Plume A, Côté G, Karimi R (2020) Scopus as a curated, high-quality bibliometric data source for academic research in quantitative science studies. Quantitative Science Studies 1(1):377–386. https://doi.org/10.1162/qss_a_00019

Baker HK, Kumar S, Pattnaik D (2021) Research constituents, intellectual structure, and collaboration pattern in the journal of forecasting : a bibliometric analysis. J Forecast 40(4):577–602. https://doi.org/10.1002/for.2731

Berlyavskiy LG, Golovko AG, Kolushkina LYu, Ponezhin MYu (2018) The formation of constitutional economics as a scholarly direction. Euro Res Stud J. https://doi.org/10.35808/ersj/1157

Bresciani S, Ciampi F, Meli F, Ferraris A (2021) Using big data for co-innovation processes: Mapping the field of data-driven innovation, proposing theoretical developments and providing a research agenda. Int J Inf Manage 60:102347. https://doi.org/10.1016/j.ijinfomgt.2021.102347

Breuer W, Perst A (2007) Retail banking and behavioral financial engineering: The case of structured products. J Bank Finance 31(3):827–844. https://doi.org/10.1016/j.jbankfin.2006.06.011

BGBuchanan 2019 Artificial intelligence in finance The Alan Turing Institute-EPSRC 10.5281/zenodo.2612537Buchanan BG (2019) Artificial intelligence in finance. The Alan Turing Institute-EPSRC. https://doi.org/10.5281/zenodo.2612537

Carayannis EG, Papadopoulos CB (2011) The innovation diplomacy concept and the Hellenic-American innovation bridge as a special case-in-point. J Knowl Econ 2(3):257–326. https://doi.org/10.1007/s13132-011-0056-5

Chakravaram V, Ratnakaram S, Agasha E, Vihari NS (2021) The Role of Blockchain Technology in Financial Engineering. Lecture Notes in Electrical Engineering. Springer, Singapore, pp 755–765

Chan NH, Wong HY (2013) Handbook of financial risk management: Simulations and case studies. In *Handbook of Financial Risk Management: Simulations and Case Studies*. https://doi.org/10.1002/9781118573570

Chen J, Wang F, Chen H (2022) Probability-conservative simulation for Lévy financial model by a mixed finite element method. Comput Math Appl 106:92–105. https://doi.org/10.1016/j.camwa.2021.12.007

Dąbrowski M (2015) 'Doing more with less' or 'doing less with less'? Assessing EU cohesion policy's financial instruments for urban development. Reg Stud Reg Sci 2(1):73–96. https://doi.org/10.1080/21681376.2014.999107

Daniali SM, Barykin SE, Kapustina IV, MohammadbeigiKhortabi F, Sergeev SM, Kalinina OV, Mikhaylov A, Veynberg R, Zasova L, Senjyu T (2021) Predicting volatility index according to technical index and economic indicators on the basis of deep learning algorithm. Sustainability 13(24):14011. https://doi.org/10.3390/su132414011

De Grauwe P, Ji Y (2019) Making the eurozone sustainable by financial engineering or political union? JCMS J Common Market Stud 57(S1):40–48. https://doi.org/10.1111/jcms.12918

Debata B, Patnaik P, Mishra A (2020) COVID -19 pandemic! It's impact on people, economy, and environment. J Public Aff 65(1):161–175. https://doi.org/10.1002/pa.2372

Ding Y, Jin M, Li S, Feng D (2021) Smart logistics based on the internet of things technology: an overview. Int J Log Res Appl 24(4):323–345. https://doi.org/10.1080/13675567.2020.1757053

Donthu N, Kumar S, Mukherjee D, Pandey N, Lim WM (2021) How to conduct a bibliometric analysis: an overview and guidelines. J Bus Res 133:285–296. https://doi.org/10.1016/j.jbusres.2021.04.070

Duffy DJ (2013) Finite Difference Methods in Financial Engineering. Wiley, Newyork

Dushnitsky G, Lenox MJ (2006) When does corporate venture capital investment create firm value? J Bus Ventur 21(6):753–772. https://doi.org/10.1016/j.jbusvent.2005.04.012

Dye RA, Glover JC, Sunder S (2015) Financial engineering and the arms race between accounting standard setters and preparers. Account Horiz 29(2):265–295. https://doi.org/10.2308/acch-50992

Edeki SO, Akinlabi GO, Egara FO, Nzeadibe AC (2020) Closed-form solutions of the time-fractional standard black-scholes model for option pricing using he-separation of variable approach. Wseas Trans Environ Dev. 16:172–179

Fagnan DE, Fernandez JM, Lo AW, Stein RM (2013) Can financial engineering cure cancer? Am Econ Rev 103(3):406–411. https://doi.org/10.1257/aer.103.3.406

Fernandez V (2011) Spatial linkages in international financial markets. Quant Financ 11(2):237–245. https://doi.org/10.1080/14697680903127403

Folqué M, Escrig-Olmedo E, CorzoSantamaría T (2021) Sustainable development and financial system: integrating ESG risks through sustainable investment strategies in a climate change context. Sustain Dev 29(5):876–890. https://doi.org/10.1002/sd.2181

Gatheral J, Jacquier A (2014) Arbitrage-free SVI volatility surfaces. Quant Financ 14(1):59–71. https://doi.org/10.1080/14697688.2013.819986

Gatti S (2008) Project finance in theory and practice: Designing, structuring, and financing private and public projects. In *Project Finance in Theory and Practice: Designing, Structuring, and Financing Private and Public Projects*. https://doi.org/10.1016/C2016-0-01618-2

Goodell JW, Kumar S, Lim WM, Pattnaik D (2021) Artificial intelligence and machine learning in finance: Identifying foundations, themes, and research clusters from bibliometric analysis. J Behav Exp Financ 32:100577. https://doi.org/10.1016/j.jbef.2021.100577

Hattori T, Ishida R (2021) Did the introduction of Bitcoin futures crash the Bitcoin market at the end of 2017? The North American Journal of Economics and Finance 56:101322. https://doi.org/10.1016/j.najef.2020.101322

Hou D, Skeie DR (2014) LIBOR: origins, economics, crisis, scandal, and reform. SSRN Electron J. https://doi.org/10.2139/ssrn.2423387

Huang C, Wang X (2019) Financial Innovation Based on Artificial Intelligence Technologies. *Proceedings of the 2019 International Conference on Artificial Intelligence and Computer Science*, 750–754. https://doi.org/10.1145/3349341.3349504

Iqbal M (2012) A Guide to Islamic Finance Principles and Financial Engineering. Edward Elgar Publishing, In The Islamic Debt Market for Sukuk Securities. https://doi.org/10.4337/9780857936219.00013

Javaid M, Haleem A, Singh RP, Suman R, Gonzalez ES (2022) Understanding the adoption of Industry 4.0 technologies in improving environmental sustainability. Sustain Oper Comput 3(January):203–217. https://doi.org/10.1016/j.susoc.2022.01.008

Jena JR, Panigrahi RR, Shrivastava AK (2023) A bibliometric analysis on financial engineering studies. Int J Financ Eng. https://doi.org/10.1142/S2424786322500396

Johnston R, Petacchi R (2017) Regulatory oversight of financial reporting: securities and exchange commission comment letters. Contemp Account Res 34(2):1128–1155. https://doi.org/10.1111/1911-3846.12297

Kafidipe A, Uwalomwa U, Dahunsi O, Okeme FO (2021) Corporate governance, risk management and financial performance of listed deposit money bank in Nigeria. Cogent Busin Manag. https://doi.org/10.1080/23311975.2021.1888679

Kalvet T, Vanags A, Maniokas K (2012) Financial engineering instruments: the way forward for cohesion policy support? Recent experience from the Baltic states. Baltic J Econ 12(1):5–22. https://doi.org/10.1080/1406099X.2012.10840508

Karadi P, Nakov A (2021) Effectiveness and addictiveness of quantitative easing. J Monet Econ 117:1096–1117. https://doi.org/10.1016/j.jmoneco.2020.09.002

Kauffman RJ, Hu Y, Ma D (2015) Will high-frequency trading practices transform the financial markets in the Asia Pacific Region? Financ Innov 1(1):1–27. https://doi.org/10.1186/s40854-015-0003-8

Kayed RN, Hassan MK (2011) The global financial crisis and Islamic finance. Thunderbird Int Bus Rev 53(5):551–564. https://doi.org/10.1002/tie.20434

Khan MA, Pattnaik D, Ashraf R, Ali I, Kumar S, Donthu N (2021) Value of special issues in the journal of business research: a bibliometric analysis. J Bus Res 125:295–313. https://doi.org/10.1016/j.jbusres.2020.12.015

Khashanah K, Alsulaiman T (2016) Network theory and behavioral finance in a heterogeneous market environment. Complexity 21(S2):530–554. https://doi.org/10.1002/cplx.21834

Kim H, Cho H, Ryu D (2020) Corporate Default predictions using machine learning: literature review. Sustainability 12(16):6325. https://doi.org/10.3390/su12166325

Kou SG (2007). *Jump-Diffusion Models for Asset Pricing in Financial Engineering* (pp. 73–116). https://doi.org/10.1016/S0927-0507(07)15002-7

Kouvelis P, Dong L, Boyabatli O, Li R (2011) The Handbook of Integrated Risk Management in Global Supply Chains. Wiley, Newyork

Koval V, Prymush Y, Popova V (2017) The influence of the enterprise life cycle on the efficiency of investment. Baltic J Econ Stud 3(5):183–187

Kumar G, Jain S, Pratap U (2020) Stock market forecasting using computational intelligence : a survey. In Archives of Computational Methods in Engineering, Springer, Netherlands

Kumar S, Xiao JJ, Pattnaik D, Lim WM, Rasul T (2022) Past, present and future of bank marketing: a bibliometric analysis of international journal of bank marketing (1983–2020). Int J Bank Market 40(2):341–383. https://doi.org/10.1108/IJBM-07-2021-0351

Kumar A, Shrivastav SK, Shrivastava AK, Panigrahi RR, Mardani A, Cavallaro F (2023) Sustainable supply chain management, performance measurement, and management: a review. Sustainability 15(6):5290. https://doi.org/10.3390/su15065290

Leo M, Sharma S, Maddulety K (2019) Machine learning in banking risk management: a literature review. Risks 7(1):29. https://doi.org/10.3390/risks7010029

Li B, Xu Z (2021) A comprehensive bibliometric analysis of financial innovation. Econ Res Ekonomska Istraživanja. https://doi.org/10.1080/1331677X.2021.1893203

Libich J, Lenten L (2022) Hero or villain? The financial system in the 21st century. Journal of Economic Surveys 36(1):3–40. https://doi.org/10.1111/joes.12437

Lin C-C, Chen C-S, Chen A-P (2018) Using intelligent computing and data stream mining for behavioral finance associated with market profile and financial physics. Appl Soft Comput 68:756–764. https://doi.org/10.1016/j.asoc.2017.08.008

Liu R, Zhan YR, Liu JP (2006) Estimating Value at Risk of a listed firm in China. *Proceedings of the 2006 International Conference on Machine Learning and Cybernetics*, *2006*(August), 2137–2141. https://doi.org/10.1109/ICMLC.2006.258609

Maringer D, Ramtohul T (2012) Regime-switching recurrent reinforcement learning for investment decision making. CMS 9(1):89–107. https://doi.org/10.1007/s10287-011-0131-1

Matiş D, Strouhal J, Giorgiana Bonaci C (2009) *Regulators and regulations for financial instruments in the context of financial crisis–two emergent countries' point of view* (pp. 345–378). https://doi.org/10.1108/S1479-3563(2009)0000009015

Matsumura K, Kawamoto M (2013) Derivative trade optimizing model utilizing GP based on behavioral finance theory. Electron Commun Japan 96(4):15–28. https://doi.org/10.1002/ecj.11469

Nagar, C. (2019). The Scope and Innovations of Financial Engineering in Financial Systems. *Working Paper*, *October*. https://doi.org/10.13140/RG.2.2.33237.47845

Osterrieder J, Lorenz J (2017) A statistical risk assessment of bitcoin and its extreme tail behavior. Ann Financ Econ 12(01):1750003. https://doi.org/10.1142/S2010495217500038

Oztemel E, Gursev S (2020) Literature review of Industry 4.0 and related technologies. J Intell Manufact 31(1):127–182. https://doi.org/10.1007/s10845-018-1433-8

Pena A, Patino A, Chiclana F, Caraffini F, Gongora M, Gonzalez-Ruiz JD, Duque-Grisales E (2021) Fuzzy convolutional deep-learning model to estimate the operational risk capital using multi-source risk events. Applied Soft Computing 107:107381. https://doi.org/10.1016/j.asoc.2021.107381

Pritchard RD (1969) Equity theory: a review and critique. Organ Behav Hum Perform 4(2):176–211. https://doi.org/10.1016/0030-5073(69)90005-1

Priyadarshini I (2019) Introduction to Blockchain Technology. Cyber Security in Parallel and Distributed Computing. Wiley, USA, pp 91–107

Qiu J, Wu Q, Ding G, Xu Y, Feng S (2016) A survey of machine learning for big data processing. EURASIP J Adv Sig Proc 2016(1):67. https://doi.org/10.1186/s13634-016-0355-x

Quinn S (2017) "The miracles of bookkeeping": how budget politics link fiscal policies and financial markets. Am J Sociol 123(1):48–85. https://doi.org/10.1086/692461

Rahman SU, Faisal F, Ali A (2022) Financial development and shadow economy: a bibliometric analysis using the scopus database (1985–2021). J Knowl Econ. https://doi.org/10.1007/s13132-022-00980-5

Rhue L (2018) Trust is all you need: an empirical exploration of initial coin offerings (ICOs) and ICO reputation scores. SSRN Electron J. https://doi.org/10.2139/ssrn.3179723

Sardana V, Singhania S (2018) Digital technology in the realm of banking: a review of literature. Int J Res Financ Manag 1(2):28–32

Schmidt AB (2011) Financial Markets and Trading. Wiley, Newyork

Sheng A (2009) From Asian to Global Financial Crisis. Cambridge University Press, USA

Singla A, Luby MJ (2020) Financial engineering by City governments: factors associated with the use of debt-related derivatives. Urban Affairs Review 56(3):857–887. https://doi.org/10.1177/1078087418802360

Souvannaseng P (2022) Liquidated: US/Japan-Chinese rivalry, financial crises, and explaining shifts in hydropower finance regimes in the mekong. Asian Perspect 46(1):49–75. https://doi.org/10.1353/apr.2022.0002

Tapiero CS (2011) Risk finance and asset pricing. Wiley. https://doi.org/10.1002/9781118268155

Turvey GC, Woodard J, Liu E (2014) Financial engineering for the farm problem. Agric Financ Rev 74(2):271–286. https://doi.org/10.1108/AFR-05-2014-0010

Woodcock KR, Barrett LB (1970) gray iron foundries: a case study. J Air Pollut Control Assoc 20(2):72–77. https://doi.org/10.1080/00022470.1970.10469376

Wu Z, Wang S, Yang H, Zhao X (2021) Construction of a supply chain financial logistics supervision system based on internet of things technology. Math Probl Eng 2021:1–10. https://doi.org/10.1155/2021/9980397

Xie H, Zhang Y, Zeng X, He Y (2020) Sustainable land use and management research: a scientometric review. Landscape Ecol 35(11):2381–2411. https://doi.org/10.1007/s10980-020-01002-y

Yalmaev RA, Grigoryeva LV, & Shkarupa EA (2021) *Financial engineering in personal finance management system*. 050020. https://doi.org/10.1063/5.0075841

Yan GCC (2011) A financial engineering approach to identify stock market bubble. Syst Eng Proc 2:153–162. https://doi.org/10.1016/j.sepro.2011.10.018

Yuan GX, Wang H (2019) The general dynamic risk assessment for the enterprise by the hologram approach in financial technology. Int J Financ Eng 06(01):1950001. https://doi.org/10.1142/S2424786319500014

Zopounidis C, Doumpos M, Pardalos P (2010) Handbook of Financial Engineering. Springer, Berlin

Zubaidi IB, Abdullah A (2017) Developing a digital currency from an islamic perspective: case of blockchain technology. Int Bus Res 10(11):79. https://doi.org/10.5539/ibr.v10n11p79