Nigerian Research Journal of Engineering and Environmental Sciences 5(1) 2020 pp. 190-197

Nigerian Research Journal of Engineering and Environmental Sciences
Journal homepage: www.rjees.com

Review Article

Financial Engineering: Concepts, Applications and Drivers of Growth

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ARTICLE INFORMATION

Article history:
Received 22 May, 2020
Revised 01 Jun, 2020
Accepted 02 Jun, 2020
Available online 30 June, 2020

Keywords:
Desk research
Derivatives
Financial engineering
Derivatives markets
Nigeria

ABSTRACT

The objective of this paper was to review the concept, tools, scope, nature, applications, and the drivers of growth of financial engineering. From the desk research, it was found that financial engineering is not one of the fields of engineering but a major discipline within finance. Financial engineering as an idea has existed from the time man started transacting financial business but its evolution as a terminology and a distinct profession is of recent origin. Therefore, financial engineering could be described as a multidisciplinary study that applies the tools of mathematics, methods of engineering, economic principles, and financial theories as solutions to problems in finance and as an aid to financial decisions of economic agents. Financial engineering plays significant roles in any economy and its potential impact in a developing economy like Nigeria is acknowledged in theoretical literature. However, most emerging capital markets lack financially-engineered products such as derivatives. It is imperative for the Nigerian government to introduce formal derivatives market after creating enabling legal frameworks and institutional arrangements needed for its smooth take off. Extensive research on financial engineering is also required for the development of derivatives market in emerging economy like Nigeria.

1. INTRODUCTION

Finance as a discipline is dynamic and universal. The dynamism inherent in it makes it a field of study that is still evolving and thus extending. The discipline combines tools and principles in other fields to facilitate financial decisions and solve financial problems of economic agents such as individuals, firms and the public sector (Akinsulire, 2011; Brigham and Houston, 2015). One of the emerging areas in finance which borrows heavily from the tools of engineering, computational finance and economic theories is financial engineering. As the world is becoming complex so do the problems of life. This brought about the need for versed and

diverse tools, models, knowledge, theories for solving human problems, especially using quantitative approach (Zopounidis et al., 2007). Veernaik (2016) opines that to acquire these needed skills, there is a need for a mastery of mathematical and managerial knowledge, thereby making the study of financial engineering a vital one in the modern days.

Financial engineering as a cross-disciplinary field relies on mathematical finance, numerical methods and computer simulations for trading, hedging and investment decisions, and financial risk management (Veernaik, 2016; Baporikar, 2018). Since the evolution of finance as a discipline in the 19th century, there have been several changes to the field. One of these changes as posited by Zopounidis, et al. (2007), is the change in its nature from a descriptive science to an analytic science, which entails the design of new financial products and the development of innovations with regard to financial instruments, processes, and solutions to problems of finance. This transformation, the authors noted further, started in late 1950s with the work of Markowitz on portfolio selection and later, during the 1970s, with the work of Black and Scholes on option pricing. These pioneering works indicate that the descriptive nature of finance was gradually becoming more analytic and quantitative one that eventually evolved into the engineering phase of finance by the late 1980s (Zopounidis, et al., 2007). However, despite all these transformations, the engineering phase has not attained its deserved popularization. Hence the need for this study. Therefore, this paper aimed to examine theoretically the concept, tools, scope, nature, applications and drivers of growth of financial engineering.

2. METHODOLOGY

This study is a review of the basic concepts, tools, scope, nature, applications and drivers of growth of financial engineering. Desk research approach was employed in the study. Data for the study was purely secondary in nature. Textbooks, journals articles, technical reports, the Central Bank of Nigeria (CBN) statistical bulletin, internet sources, etc., constitute the sources of the data employed in this paper. In the search of the data, various key components of the study, like meaning, concepts, scope, tools, nature, drivers of growth of financial engineering were specifically sought for in the various sources consulted. They were identified, sorted, selected, read and digested before assemblage into a report under their respective categories.

3. RESULTS AND DISCUSSION

3.1. Concept of Financial Engineering

The term engineering refers to application of science and mathematics in the designing, testing and building of machines, structures and processes (University of Bath, 2020). It is the ensemble of intellectual activity, which allows creation of a system that functions efficiently in conjunction with other systems (Moskvitin et al., 2016). Thus, engineering could be described as the creative use of tools, methods, principles, laws of science to develop, design, build and create things such as structures, manufacturing processes, apparatus, machines, buildings, bridges, and other products. A professional who practices engineering is called an engineer. Engineering as a discipline has branches such as electrical, civil, mechanical, chemical, mining, electronic/electrical, marine, aerospace, computer engineering, etc.

Finance is the art, science and business of managing money and monetary affairs of individuals, firms or governmental entities. According to Tapiero (2013), finance seeks to create and manage rationally and efficiently, financial markets, liquidity, exchanges and risks based on the basic tenets of economic models. Finance is the study of economic agents' behavior in allocating financial resources and managing risks across alternative financial instruments and in time under condition of uncertainty (Madsen, 2013). Therefore, in a narrow sense, financial engineering could be described as the creative application of the methods and tools in engineering, most especially quantitative techniques, as well as economic principles, integrated with financial theories in the building, creating, developing, and designing of financial models, products, instruments and processes, as solutions to problems in finance. Ali (2015) also maintains that in a narrow sense, only practitioners who are educated in the full range of tools of modern finance and whose work is informed by financial theory could be regarded as financial engineers. It is sometimes narrowed further to mean only those practitioners whose work involves creating and designing new financial products and strategies.

Financial engineering, sometimes called financial mathematics, mathematical finance or computational finance, entails financial theory, methods of engineering, tools of mathematics and the practice of programming. It can also be described as the application of technical methods, most especially from computational finance, mathematical finance, fields of computer science, statistics, economics, in the designing of innovative financial products and for solving of financial problems (Baporikar, 2009; Shalini and Duraipandian, 2014; Ali, 2015; Sayyed, 2015). Financial engineering combines financial and economic theory with the mathematical and computational tools needed to design and develop financial products, portfolios, markets, and regulations (University of Conterbury, 2019). It entails the application of financial theory, as well as the implementation of advanced methodological tools and quantitative analysis techniques as solutions to financial decision problems (Zopounidis et al., 2007). Financial engineering derives its name perhaps because it initially borrowed heavily from the tools of engineering. Alhasadi and Ilhusadi (2019) also see financial engineering as the use of financial instruments in redesigning an existing financial product into another ones having properties that are more desirable and beneficial. In addition to derivatives, others financially-engineered products include equity and debts products, insurance products, and digital banking services (Nagar, 2018).

Furthermore, while financial engineering is not an engineering discipline but a financial discipline which deals with the creation of new and improved financial products through innovative design or repackaging of old financial instruments. It also makes use of financial instruments to restructure an existing financial profile into one having more desirable properties (Felix et al., 2015).

From the above definitions, it is can be seen that financial engineering is multidisciplinary in nature. It borrows heavily from engineering methods and tools, hence the word financial engineering. It is a profession with its own tools, models and principles. It is neither a mere set of tools nor a mere amalgam of terms. It is a field under finance and not under engineering as some authors claimed. It has two main perspectives, narrow and broad perspectives.

3.2. Scope of Financial Engineering

The field of financial engineering has attracted people from diverse backgrounds and perspectives. In addition to financial theories, assorted fields of studies contribute to the field. Hence, the scope of financial

engineering has been increasing greatly to the extent that it investigates structured products, risk management, re-insurance firms, finance, tools, market mechanisms, banks, auditing firms, investment, consulting firms and other (Veernaik, 2016). Figure 1 presents diverse disciplines that contribute to financial engineering.

For the sake of giving the field of financial engineering its proper shape, each of the fields interact and interrelate to lend their inputs for the growth and development of financial engineering as discipline.

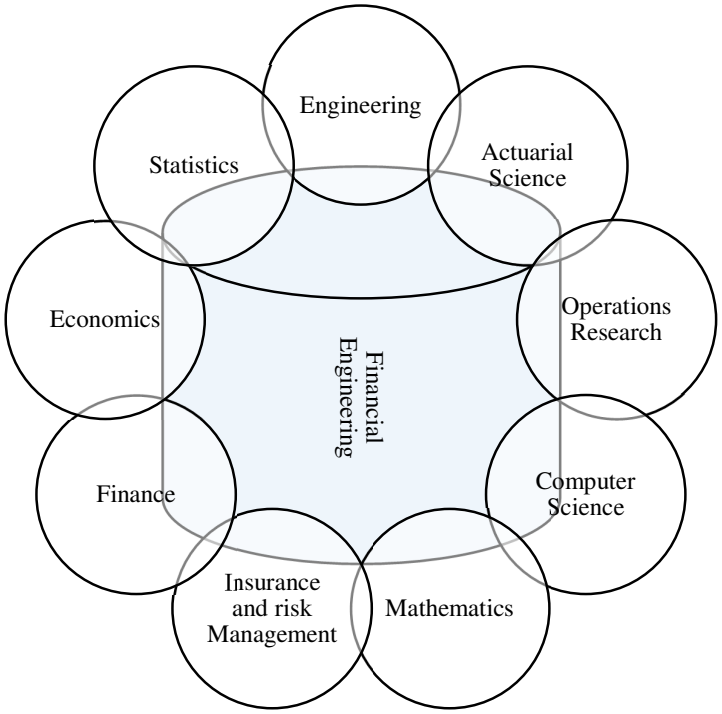

Figure 1: Scope of financial engineering

3.3. Tools of Financial Engineering

Tools required for financial engineering have been classified into two, namely, conceptual tools and physical tools. Conceptual tools are sets of concepts and ideas which underlie finance as a formal discipline. Examples of conceptual tools are concepts like accounting relationships, hedging theory, theory of valuation, portfolio theory, risk and return analysis, accounting relationships, and taxation of business, interest rates and exchange rates, speculation, arbitrage, and market efficiency (Zopounidis et al., 2007; Veernaik, 2016).

In contrast, physical tools are special processes and instruments used in combination by financial engineers in order to perform a specific task or achieve a particular purpose. The processes include different trading mechanisms and techniques while the instruments include various securities such as futures, swaps, options, and equities (Zopounidis et al., 2007; Veernaik, 2016). This implies financial-engineered products are mostly derivatives. Derivatives as defined by Nwachukwu (2020) refers to securities that derive their value from an underlying security or asset. Examples include futures, forwards, options, swaps, etc.

Trading in derivatives in Nigeria has been in the form of over-the-counter (OTC) transactions. Table 1 shows a sample of values of financial derivatives in the statements of financial position of banks in Nigeria. At present, there is no formal market for trading in derivatives in Nigeria but according to Nwachukwu (2020), Nigeria's Securities and Exchange Commission (SEC) identified the development an efficient formal derivatives trading market is one of its top priorities in year 2020.

Table 1: Composition of derivatives in the statements of financial position of banks in Nigeria (CBN 2018)

Years	Merchant banks (in Billion Naira)	Deposit money banks (in Billion Naira)
2014	0	19.14
2015	0	25.14
2016	0.01	194.84
2017	8.07	781.14
2018	48.58	1058.42

As shown in Table 1, between years 2014 and 2015, merchant banks in Nigeria had no derivatives transactions recorded in their statements of financial position (SOFP). However, deposit money banks (DMBs) have N19.14 billion and N25.14 billion for 2014 and 2015 respectively. Furthermore, in years 2016, 2017 and 2018 merchant banks had a total of N0.01 b, N8.07 b and N48.58 b respectively in their SOFP. N194.84 b, N781.14 b and N1058.42 b were traded in financial derivatives by DMBs in OTC market in years 2016, 2017 and 2018 respectively. These values were traded over the counter.

3.4. Drivers of Growth of Financial Engineering

These are factors that encourage the growth of financial engineering. These motivating factors as shown in Figure 2, are commonly grouped by scholars into two classes, namely, environmental factors and intra-firm factors (Shalini and Duraipandian, 2014; Veernaik, 2016; Thakkar, 2017; Alhasadi and Ilhusadi, 2019).

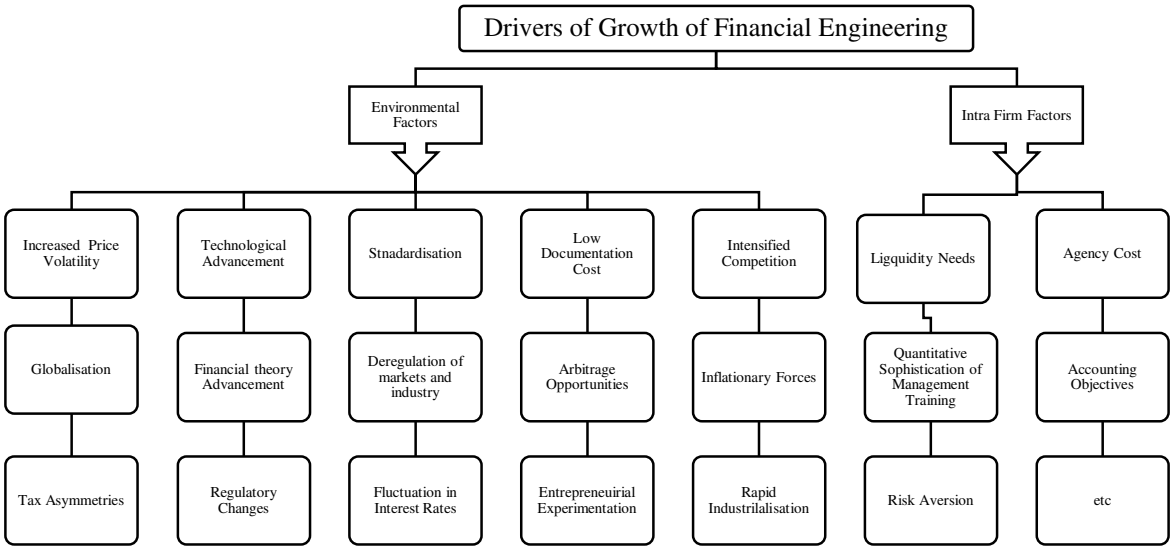

Figure 2: Drivers of growth of financial engineering

Environmental factors (also external factors), are factors that are external to the firm and uncontrollable by the firm but they affect the firm's performance. On the other hands, intra-firm factors, (also referred to as internal factors), simply refers to factors that are internal to the firm and over which the firm can exercise some level of control (Veernaik, 2016; Nagar, 2018).

3.5. Applications of Financial Engineering

Financial engineering can be applied in the field of derivatives pricing, corporate finance, financial regulation, portfolio management, risk management, execution, the value of options, trading, and structured products (Veernaik, 2016). In addition, financial engineers could function in the securities, banking, and financial management and consulting industries, or as quantitative analysts in corporate treasury and finance departments of general manufacturing and service firms (Baporikar, 2018). Furthermore, financial engineers are involved in financial modelling, financial analysis, development of simulations, forecasting of market behavior, computer programming, financial risk management, and they also act as investment managers, bankers or traders (Thakkar, 2017). A financial engineer could also function as investment broker/traders, quant trader, actuary, quantitative research analyst, risk analyst/manager, business analyst, statistical analyst, data scientist, investment analyst (University of Conterbury, 2019). Other areas where financial engineering techniques are employed include investment banking, forecasting, risk management software, corporate strategic planning, securities trading and financial risk management, derivatives trading and risk management, investment management, pension scheme, insurance policy, mortgage agreement, lottery design, islamic banking, currency peg, gold and commodity valuation, collateralized debt obligation, bargaining, and market mechanism design (Vrijling and Verlaan, 2015; Baporikar, 2018).

3.6. Nature of Financial Engineering

Financial engineering is the emergence of a new funding pattern that differs from the traditional funding (Ibraheem, 2013). Financial engineering as an idea is not a new phenomenon. It is as old as financial transactions. However, its evolution as a terminology and specialization is relatively recent (Ibraheem, 2013; Shalini and Duraipandian, 2014; Thakkar, 2017). Financial theory constitutes the underlying knowledge required to address financial engineering problems, some synthesis and analysis are also necessary for innovation. Thus, in financial engineering, there is an extensive use of advanced decision analysis and modeling tools to manage the complexity of the financial and business environments of modern days (Zopounidis et al., 2007). Thus, financial engineering is playing an important role as a major discipline within finance (Veernaik, 2016).

It can be inferred from the above that financial engineering is an emerging field of study under finance, hence, is relatively new compared with traditional specialisations in finance like public finance, corporate finance, international finance and others. The field is multi-disciplinary, borrowing from other fields as shown in Figure 1. Therefore, financial engineering as a discipline and a terminology, is a new dawn considering its recent evolution and development but if it is looked at as an idea, it is an old school idea, which is as old as financial transactions. In addition, financial engineering is not a mere amalgam (merger) of different disciplines without coherence and clear boundary of meaning, applications and implications. Though, still evolving and borrowing heavily from the tools and methods of mathematics, statistics, operations research, financial engineering's importance and applications will continue to expand, as far the

complexity of business, globalisation, competitions, uncertainty in macroeconomic variables and other factors depicted in Figure 2 persist and increase.

4. CONCLUSION

The paper reviewed the concepts, tools, scope, nature, applications, as well as drivers of growth of financial engineering. As a major discipline within finance, financial engineering is multidisciplinary in nature, thereby borrowing from fields such as economics, engineering, mathematics, statistics, economics, actuarial science, insurance and risk management. Financial engineering derives its name perhaps because it initially borrows heavily from the tools of engineering. The paper holds therefore that financial engineering is a profession not a mere kit of tools, though it has its own tools, methods, principles and techniques. The review also reveals that financial engineering is not a new idea but its evolution as a distinct terminology and a discipline is relatively new. Financial engineering could therefore be described as the applications of methods and tools of engineering, mathematics, statistics, economics, financial theories and principles as solutions to the problems and as aids to financial decision of individuals, firms and governmental bodies. Therefore, it is imperative that the Nigerian government introduce the formal market where financially-engineered products could be traded after creating enabling legislations and institutional frameworks vital for its smooth take off. Similarly, extensive research is also needed in the area of financial engineering in Nigeria, for this will provide theoretical and empirical postulates to further facilitate the development of the derivatives market, as well as the field of financial engineering.

5. ACKNOWLEDGMENT

This research work did not enjoy any funding. However, the author wishes to appreciate his employer for providing the academic environment where intellectual undertaking like this could be carried out.

6. CONFLICT OF INTEREST

There is no conflict of interest associated with this work.

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