

The effects and implications of Financial Engineering in the corporate world – A review

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Abstract:– Financial engineering is the application of mathematical methods to the solution of problems in finance. It is also known as financial mathematics, mathematical finance, and computational finance. Financial engineering draws on tools from applied mathematics, computer science, statistics, and economic theory. With the growth of commerce and corporate governance, the use of financial engineering as a tool and a model for assessing the growth of organizations has become significant thereby raising the bar for competitiveness and efficiency. Financial Engineering can be used for various aspects – to showcase and build models for the turnovers in a firm, to solve hurdles on the basis of mathematical modeling and to build upon a set of applications that can further be implied in the corporate world. With the growing importance of these aspects as domains, the research paper mainly entails in presenting the different uses of financial engineering in management and reduction of the common financial threats that are mundane in the world of finance. The paper will present information on how to use financial engineering effectively through its different building blocks to eliminate management threats. The paper will also ensure that the use of financial engineering is geared to having an effective and efficient market that will ensure the increase of trading information and present a near perfect market. With the help of empirical evidence and past papers, this study provides a whole new set of literature review, therefore signifying its importance. The findings showed that financial engineering led to organizational growth, efficiency, building of reliable models and so on and forth. If done in a set manner, financial engineering can lead to great growth and development.

Keywords:– Financial Engineering, threat assessment, building blocks, mathematical modeling, liability management

I. INTRODUCTION

The financial threats faced by organizations have increased extremely over the last two decades and the payoffs of managing threat successfully are very high. In response to this increased threat and the incentive to manage it, older instruments of threat management such as forwards and futures have been expanded in scope, and many new instruments devised. The process of adaptation of existing financial instruments and processes to develop new ones so that financial market participants can effectively cope with the changing situations is known as financial engineering (Marshall, 2006). Financial engineering is well on the way to becoming an independent discipline with its own professional bodies. An example is the American Association of Financial Engineers (AAFE), set up in 2006 (Marshall, 2006). With these considerations, this research aims to provide empirical evidence on the growth of financial engineering and its uses along with methods to combat stigma in a firm while suggesting other leads for development, growth and further research.

II. RESEARCH METHODOLOGY

The research mainly undertakes a qualitative research approach through collection of data from relevant publication on past research to ensure that the research paper on financial threats is prepared and geared towards the research objectives. Empirical evidence is gained through past papers and literature review from scholarly sources. This paper takes the shape of a descriptive research, wherein the researcher has adequate knowledge on the topic at hand and uses practical concerns and approaches to bring about the results. The methods used are both theoretical and empirical. Theoretical concerns are met through readings of qualitative data, while empirical research is built by assessment of these present sets of data. Analysis and Mathematical Modeling has effectively formed the roots of this research, and with the help of brief descriptions and understandings of the technicalities of the financial world, the research forms a database that further explores the world of financial engineering. This section provides insights on the research methodology and the most appropriate methods used in the carrying out of this study. It consists of sections covering the research purpose, study design, empirical evidence, theoretical modelling, ethical considerations, and challenges encountered in the course of the study. This study incorporates the theoretical study design and the empirical research design. The theoretical study design involves the creation of different mathematical models while the empirical research design will involve the use of the scholarly articles and books as a means of lending credence to the assertions

therein. The pros of adopting such a design is that it takes less time in adoption and implementation, is cheap and makes it easier to compare data in order to come up with reliable and valid findings.

III. PROBLEM STATEMENTS

- What are the effects of financial threats to organizational, employees, the market and the general economy of the region?
- In what way can financial threats be understood through financial engineering and be provided with an effective solution?
- How can organizations benefit from the use of financial engineering and its applications in a real-set of corporate practices?
- What are the current problems in the management of financial engineering and how can various building blocks overcome these stigmas?

IV. RESEARCH SIGNIFICANCE AND PURPOSE

In this paper, we take a look at threats, the fundamental tools/methods of threat management, and the role of financial engineering in today's world. This research aims at showing the importance of threat management tools in corporate governance. It being a descriptive research, attempts to provide a description of different aspects that have a correlation with the situations or events within an organization, in this case financial threats. Therefore, the purpose of having such a study would be to generalize the outcomes so as to develop theories. Further, it takes the form of a descriptive research as the researcher only possess adequate knowledge about the problem in question and there is limited intention to find out the relations between the causes and effects of the problem. It will adopt this approach as secondary data will be involved in the investigation of the problems to be solved by this research study. For this study, secondary data will be derived from the literature review section and theories from these used to support the empirical evidence.

V. RESEARCH RATIONALE

While financial engineering has been on the forefront in development and growth, a working financial engineering management tool is important in ensuring success of corporate organizations in any institution. This research paper is therefore justified as it offers the corporate organizations to analyze and make a choice of the best model that they can apply in order to enhance corporate governance within their entities and to avoid further financial threats, such that they can increase efficiency of the firm. The research paper is aimed at understanding the significance and role of financial engineering as a whole and taking into concern its pros and cons. The realization of the effectiveness of mathematical, statistical and computational models will further lead to organizational growth and efficacy and this is what the study aimed to achieve. To a greater extent, the discussed and analyzed buildings blocks are effective tools in corporate governance in modern-era firms.

VI. SCOPE OF THE RESEARCH

This research study covered different financial engineering management models and how they enhance corporate governance. The concentration of this study is on the building blocks of financial engineering, their understandings and relationship to firms and corporations and their assessment and analysis. The research seeks to find the relationship between financial threats and financial models and therefore suggests reasons and factors that directly or indirectly played a significant role. Therefore, the study will involve the analysis of financial engineering using the various models and identify their efficacy in corporate firms. Further, the findings of the study will be compared with the available scholarly articles obtained in the literature review in order to make reliable and viable conclusions.

VII. RESEARCH QUESTIONS

The research will address the following questions:

1. Does having a financial engineering management tool enhance corporate performance?
2. What are the implications of not having a financial management model on the corporate governance of the organization?
3. How can financial engineering tools help in the identification, assessment and prioritization of financial threats?
4. How can the identification, assessment and prioritization of risks help in stopping, countering and management of the risks within the organization?

VIII. RESEARCH HYPOTHESIS

H1 A financial engineering tool fosters corporate performance in organizations.

H2 Financial engineering tools help in identifying, assessing and putting priority of the financial threats that the organization is likely to come across.

H3 Financial engineering tools help in the stopping, management and the countering of threats.

IX. RESEARCH AIMS AND OBJECTIVES

The aim of the research is to analyse the importance of financial engineering as a role in firms and its building blocks in corporate performance and give a recommendation on the most desirable model that can be adopted by these entities in their day to day activities. The aim of the paper is also to understand the technicalities of the various terms and assess these terms to further develop and strategize firm productivity.

Objectives of the research will be:

1. To find out if financial engineering enhances corporate performance.
2. To find out if the financial engineering tools can help in the identification, assessment and the prioritization of the financial threats that can be incurred by the organization.
3. To find out how the financial engineering tools can be used in stopping, managing and countering of threats.

X. LITERATURE REVIEW

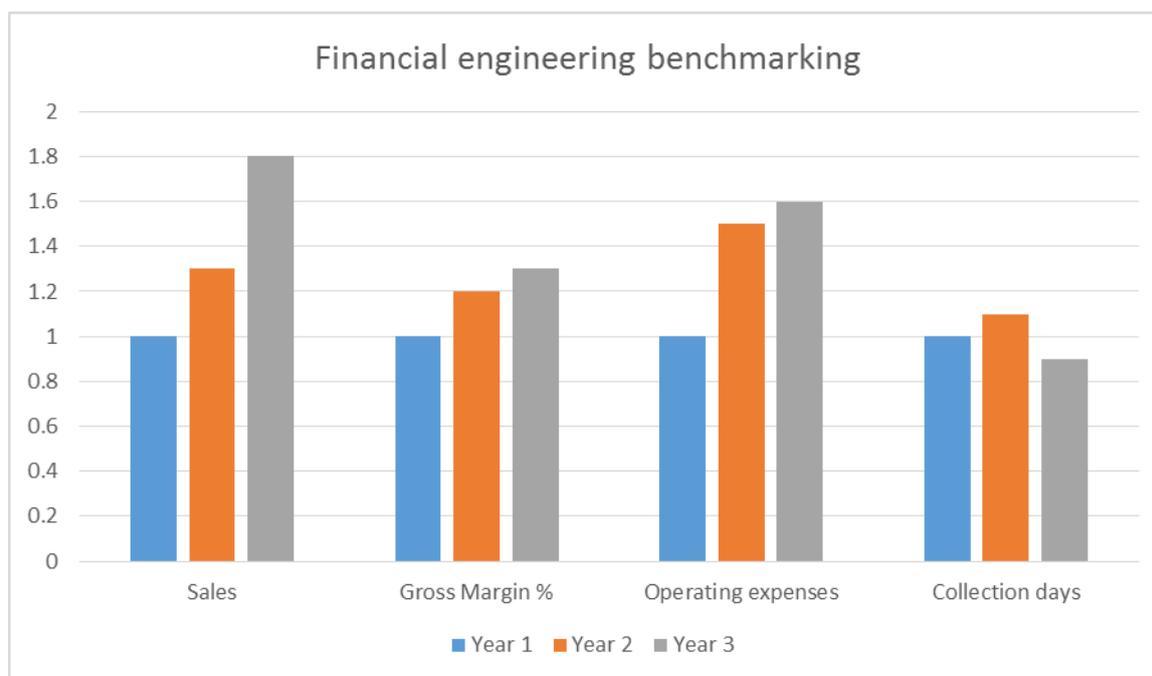
A. Financial Threat

The term "financial threat" covers the range of threats affecting financial outcomes, faced by a firm. Financial threat is essentially of two kinds: systematic and unsystematic. *Systematic threat* is that portion of threat which cannot be diversified away. Some of its components are listed below.

1. **Business threat** is the threat of fluctuations in sales revenue. It arises from macroeconomic factors such as economic swings and deregulation, and demand factors such as seasonality of demand. This threat is not totally systematic, however, and some of it can be reduced by diversification of the firm's operations. The threat of property loss, and product liability suits, can be insured against (Shapiro,2000: 215).
2. **Financing threat** arises from leverage. It is possible to minimize it by restricting the amount of debt in the firm, even though there may be tax advantages to borrowing (Shapiro,2000:215).
3. **Inflation threat** arises from unanticipated inflation. In international trade, it arises from movement away from purchasing power parity (PPP). Hedging is difficult in this case (Walsh,2002:56).
4. **Default or credit threat** is the threat of default of payment by debtors of the firm. Large banks use credit rating agencies, such as Moody's Investor Services and Standard and Poor's Corporation, to rate borrowers. Though this threat is mostly systematic, it can be diversified in some cases (e.g., by banks holding a large portfolio). Some forms of credit threat can be insured against, e.g., export credit (Shapiro, 2000: 225).
5. When it is difficult to buy or sell a financial instrument at its market price, then there is **marketability or liquidity threat** associated with it. This threat is diversifiable and also completely systematic. Some insurance organizations insure this threat to some extent (Shapiro, 2000: 225).
6. **Operating threat:** Operating leverage is the commitment of the firm to fixed production charges (fixed costs). The greater the operating leverage, the greater the threat to the firm. Reducing operating leverage wherever possible, helps (Shapiro, 2000: 226).
7. **Political threat** can be both domestic and foreign; it is particularly high when operating in some politically unstable Third World countries. This threat is highly systematic and diversifiable (Walsh, 2002:55).

Unsystematic threat comprises primarily of price threats.

1. **Interest rate threat** arises both from fixed and floating rate debt. Unanticipated changes in floating interest rates can cause costs to rise. However, Putnam (2000) shows that the **real** interest rate on floating-rate debt is more or less fixed, while it is floating in case of fixed-rate debt. Thus the real interest costs are known with certainty in case of floating-rate debt. Effectively, therefore, floating-rate debt offers a long-run hedge against inflation threat (Putnam, 2000:241). It is clear that inflation and interest rate threats are closely related. At the same time, a fixed rate debt can cause financial difficulties in case interest rates drop. This is therefore a major threat faced by almost all companies. It can be hedged against in many ways.
2. **Currency (or foreign exchange) threat** arises when cash inflows or outflows take place in foreign currency. This threat can be either diversified or hedged.
3. **Commodity price threat** arises from unanticipated changes in commodity prices and can be hedged.



Graph 1: Financial engineering benchmarking outline

A. Principles of Managing Threat

Financial literature has concerned itself mainly with the systematic threat of a firm, measured through its beta. In fact, as per the capital asset pricing model, not managing unsystematic threat does not increase the rate of return required by investors. However, by significantly lowering the level of the firm's expected cash flows, it can and does, in practice, reduce the value of the firm. It is necessary therefore to manage unsystematic threat in cases where it could adversely impact on a firm's existence (Shapiro, 2000). Total threat is the sum of the systematic and unsystematic threats. Shapiro and Titman (2000) advocate a *total threat approach* to threat management. Total threat, being the sum of systematic and unsystematic threats, should be considered by the firm. The objective of the shareholders would then be to search for an *optimal threat profile*, where the marginal cost of bearing threat equals the marginal cost of managing it.

Threat management requires the identification of the threats to which the firm is exposed, quantification of these exposures - wherever possible, determination of the desired outcomes, and engineering a strategy to achieve these outcomes (Marshall, 2006: 239). A look at the coverage ratios is a good first step. But for detailed identification of threat, a series of cash budgets must be prepared using different economic variables and considering the use of different threat-reducing mechanisms (Shapiro, 2000: 222). Each time, the threat must be identified/ evaluated in terms of the probability of not being able to meet essential payments/ obligations.

Wherever possible, threat should be quantified. Non-financial organizations can carry out a sensitivity analysis by making a computer model which determines the relationship of inputs/ outputs/ sales, etc., to different prices, such as interest rates (Marshall, 2006: 261). By varying prices, their effect on pre-tax income can be determined. Alternatively, the historical sensitivity of the company's equity value to changes in prices can be measured. The coefficients of a simple linear regression are used to estimate the sensitivity of the value of the firm to changes in the respective variables (Smith, 2002: 42). This approach is similar in some ways to determining the beta under CAPM.

Financial organizations can measure the degree of interest rate threat through gap and duration analysis. Gap is the difference between RSA and RSL, where RSA is the market value of the rate sensitive assets and RSL is the value of the rate sensitive liabilities. Using gap, the impact on the firm of changes in the interest rate is given by $\Delta NII = \text{gap} \times \Delta r$, where NII is the net interest income, and Δr represents the change in interest rate (Smith, 2002:36).

The measure, duration, which was developed in 1938 by Frederick Macaulay, is the most widely used measure of interest-rate sensitivity of an asset, and is the effective maturity of an asset/liability expressed in units of time. The Macaulay duration is given by:

$$D = -\frac{(dS/S)}{(dR/R)}$$

Where S is the instrument's spot price and R equals 1 plus the asset's yield (for example, yield to maturity). Thus, D measures the response of price to a proportional change in the interest rate (Martin, 2000:529). If V is the value of the firm and Δ represents the change operator, then,

$$\frac{\Delta V}{V} = \frac{\Delta(1+r)}{(1+r)} \times D \quad \text{(Smith,2002:38)}$$

In this process of threat measurement, it is essential to understand the underlying determinants of the threat. In case of interest rate threat, the underlying factor would largely comprise of inflation. Therefore, the management of interest rate threat and inflation threat will have to go together (Putnam, 2000). As emphasized earlier, more important is to place the threat in perspective. If the company is not threatened by bankruptcy if prices move then a more passive strategy, involving perhaps a periodic monitoring of overall corporate exposure is probably sufficient. (Putnam, 2000:242). These considerations will help the firm to determine the desired outcomes of threat management.

B. Designing a suitable strategy:

The final step is the design of an appropriate strategy. There are three fundamental ways of managing threat: insurance, asset/ liability management, and hedging. We discuss these below.

1. **Insurance** is available against some threats (but not, generally, against price threats). However, there are usually other cheaper alternatives to insurance available. This is because insurance organizations have to return a profit after taking into account things like moral hazard and adverse selection which steeply raise their costs (Marshall, 2006:154).

2. **On-balance sheet asset/ liability management:** In this method, the firm has to hold the right combination of on-balance sheet assets and on-balance sheet liabilities, based on the principle of immunization (Marshall, 2006:155). Immunization was proposed by F.M. Remington in the early 1950s. To immunize threat, one has to select assets so that not only the present value, but also their duration equals those of the liabilities, such that:

$$\text{Duration of assets} \times \text{Market value of assets} = \text{Duration of liabilities} \times \text{Market value of liabilities}$$

There is problem associated with immunization. As prices change, the same process of asset/liability adjustment has again to be carried out, which can prove extremely expensive, especially during periods of extremely volatile interest rates (Martin,2000:530). Further, hedges often do much better (Marshall,2006: 164).

Apart from immunization, some price threats, such as foreign exchange exposure resulting from overseas competition can also be managed by directly borrowing in the competitor's currency or by moving production abroad. These are also on-balance sheet, but in general, these are costly solutions (Smith,2002:43).

C. Off-balance sheet hedging:

In hedging, ideally, there have to be two investments (say, A and B) that are perfectly correlated; one takes a temporary position by buying one and selling the other, so that the net position is absolutely safe. Though similar in some ways to asset/liability management, hedging is primarily off-balance sheet. Sometimes, however, a hedge can take the form of an on-balance sheet position (Marshall,2006:165). The following equation holds:

$$\text{Expected change in value of A} = a + \frac{\Delta(\text{Change in value of B})}{\text{value of B}}$$

Here β measures the sensitivity of changes in A to changes in the value of B, and is called the hedge ratio. The view that states that ideally β should equal 1 is now viewed unfavorably and is called the naive view.

But Johnson (1960) and Stein (1961) took a portfolio approach to hedging. In the case of futures, for example, the goal of hedging, they felt, should be to minimize the variance of the profit associated with the combined cash and futures position. Ederington extended this approach further in 1979. In the Johnson/ Stein/ Ederington (JSE) method, the spot price is regressed against the futures price using an ordinary least squares regression. The threat minimizing or the *minimum variance hedge ratio* is then given by the slope of the regression line (Marshall, 2006:517).

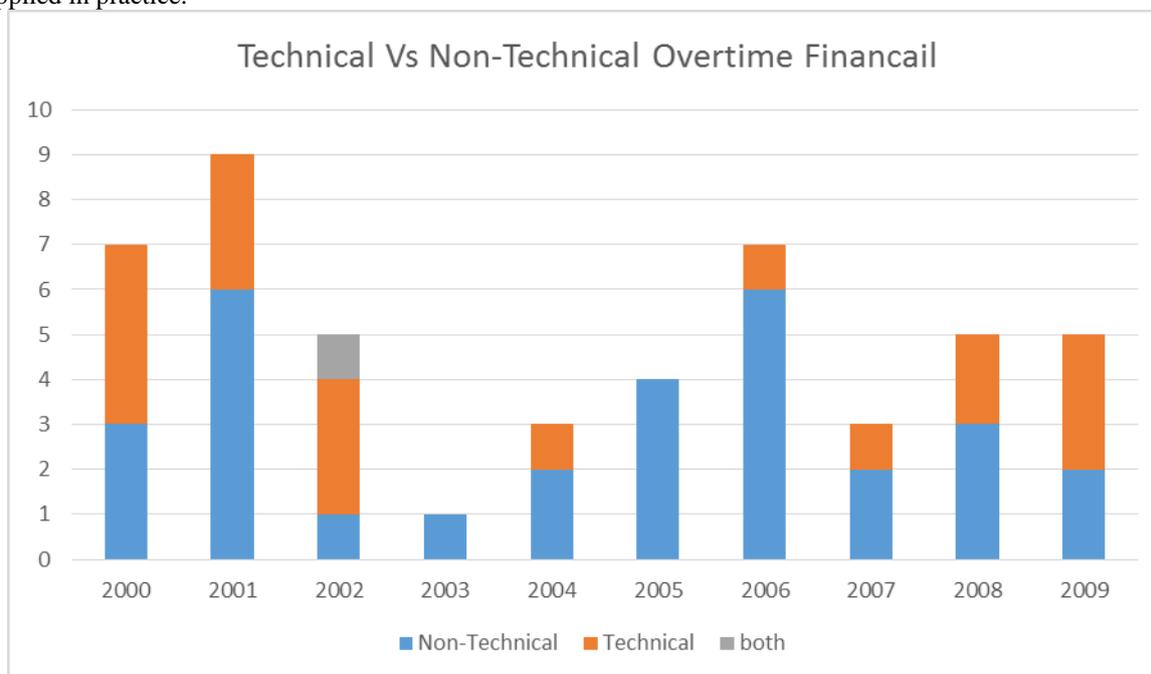
In this paper we focus on hedging as the chief method of threat management.

D. Hedging and financial engineering:

Hedging and financial engineering: Financial engineering has been defined as "the design, the development, and the implementation of innovative financial instruments and processes, and the formulation of creative solutions to problems in finance" (Marshall, 2006:3). This is a very broad definition, but the primary objective of financial engineering (FE) is to meet the needs of threat management. FE takes a *building block approach* to the building of new instruments. This approach was first demonstrated by Black and Scholes (1973) in considering a call option as "a continuously adjusting portfolio of two securities: (1) forward contracts on the underlying asset and (2) threat less securities" (Smith, 2002:50). Most of the hedges can be constructed from futures, forwards, options, and swaps, which are now known as the *building blocks of financial engineering*. By combining forwards, options, futures and swaps, with the underlying cash position, a firm's threat exposure can be manipulated in a practically infinite variety of ways.

XI. THE BUILDING BLOCKS OF FINANCIAL ENGINEERING

In this section we take a brief look at the building blocks, before going on to see how this approach is applied in practice.



Graph 2: Technical vs. Non-Technical overtime financial

A. Futures contracts:

In futures contracts, the sale and purchase of a specified asset at some specified future date is contractually agreed to, at a price determined now. The buyer places a small initial margin, usually tendered in T-bills or other forms of security, with the broker. Essentially, therefore, a position can be taken without investment in the futures market, and they are therefore off-balance sheet transactions (Marshall, 2006:281). Changes in the contract price are settled daily, with each trader marking his position to market (Copeland, 2000:304). If the margin falls below a point, a margin call is made on the buyer. This process by and large eliminates credit threat. Whereas a few major instances of default have occurred, e.g., the default of silver

contracts by Hunt Brothers, it is true that in general there is an extremely low default rate in futures (Ross, 2002:656). Finally, at the time of delivery the buyer receives (wherever feasible) the asset which was purchased, by paying the contract price.

Futures can be used to hedge against commodity-price threat, interest-rate threat, and exchange-rate-threat (Marshall, 2006:283). The main types of futures are commodities futures, financial futures and futures on indices. The first organized commodity futures market was the Chicago Board of Trade (CBT), established in 1848. The first financial futures contract was introduced on October 20, 1975, by the CBT. Financial futures markets are now much larger than traditional commodity futures markets (Martin, 2000:519).

Financial futures are used primarily to trade interest rate threat. The markets for financial futures are very liquid; and of course there is no cost of storage. Most financial futures contracts fall into three categories:

1. *Interest rate futures:* These include futures on interest bearing instruments such as T-bills, T-notes, T-bonds, certificates of deposit, Eurodollars, etc., are a popular and useful method of hedging interest rate threat. These contracts enable borrowers to lock in interest rates for some future period.
2. *Foreign currency futures:* These are available in all major currencies, and are used for hedging foreign exchange threat.
3. *Share price index futures:* The first of these was introduced in the U.S.A. only in 1982 (Van Horne, 2002:725). They are traded on the Standard and Poor's 500 index, the New York Stock Exchange Composite index, and the Value Line index (Copeland, 2000:316). These are obviously non-deliverable. Instead, these are settled in cash by marking to the market "at the closing value of the respective underlying spot stock market index on the last trading day" (Martin, 2000:522).

Some issues of interest relating to futures contracts are dealt with in Annexure II (1).

B. Forward contracts:

These are similar to futures. Here the owner of the forward contract is obliged to buy a specified asset on a specified date at the exercise price specified in the contract. No payment is made at any time at the commencement or during the term of the contract, making it an off-balance sheet instrument (Smith, 2002:45). Forwards seem to have a flaw. "Whichever way the price of the deliverable instrument moves, one party has an incentive to default. There are many cases where defaults have occurred in the real world"(Ross, 2002:655). Therefore, forward contracts usually involve counterparties who have prior knowledge of each other.

Though the oldest among financial instruments hedging threat, forward markets continue to thrive in spite of the subsequent emergence of futures markets - which are very similar to futures in many ways - because of different clienteles and other reasons. First, forward contracts are tailored to fit the needs of the customer. Second, futures do not exist for all commodities and on all financials. Third, there is a difference in accounting treatment between futures and forwards in some countries. And lastly, there is the likelihood of a possible mismatch between the length of the hedger's hedging horizon and the maturity date of the futures. Forwards take care of this. There are many interesting differences between futures and forwards. These are discussed in Annexure II.

The forward markets in currencies are the most highly developed of all the forwards markets. Large banks buy and sell forward currency, usually for periods up to 1 year ahead. In the case of the major currencies forward contracts of up to 5 years or more are now common (Brealey,2000:618).

C. Swaps:

The term "swap" covers a range of transactions "where two or more entities exchange or swap cash flows in the same or in two or several different currencies and/or interest rate bases for a predetermined length of time" (Das, 2007:17). Swaps are used primarily to hedge against interest rate and foreign exchange threats. The first currency swap was introduced in 1976, and interest rate swap only in 1981. But in spite of this, swap markets now overwhelm any other financial innovation by the sheer volume of transactions. A survey undertaken by the Federal Reserve Bank of the USA in 2007 (Eiteman,2006:91) showed that 64% of all interbank foreign exchange transactions were spot transactions, a massive 27% were swap transactions, and only 4.2% were forward transactions. Interest rate swaps now dominate the market for swaps. In this type of swap, the two different interest rates determine the cash flows.

Swap financing transactions can be classified into four (Das, 2007:17). The first category is the parallel or back-to-back loans. The second is swap transactions, comprising, *inter alia*, of currency swaps, currency coupon swaps, interest rate swaps, basis rate swaps, commodity swaps, swaps with timing mismatches, swaps with option-like payoffs (swaptions, also called contingent swaps or option swaps), deferred swaps, forward swaps, circus swaps, principal only swaps, amortizing swaps, zero coupon swaps, and long-dated or long-term foreign exchange contracts (LTFX). The third category is the forward rate agreements (FRAs), and lastly we have the caps, collars and floors. A further discussion on swaps is given in Annexure II (3).

D. Options:

In an options contract, "one party has the right, but not the obligation, to do something - usually to buy or sell some underlying asset" (Marshall, 2006:338). Of course, the seller of the options contract has an absolute obligation. When the buyer has a right to buy, then it is a *call* option, and when the right is to sell, it is a *put*. The price paid for the option is in the form of a flat up-front sum called premium. Options that can be exercised only on the maturity date are called European options, and those which can be exercised at any time are called American options. Most of the traded options are American options.

Trading in call options began on the Chicago Board Options Exchange (CBEO) in April 1973. The paper by Black and Scholes (1973) appeared at about the same time (Weston, 2007: 479). Thereafter there has been a phenomenal growth in option trading. Much of this has been fueled by the standardization of contracts and the consequent lowering in transaction costs. The fundamental use of options is in trading threat in an asymmetric manner.

Apart from single-period options such as calls and puts, there are many others. Multi period options - which include interest rate caps, interest rate floors, and interest rate collars - are important because they are easily combined with other instruments, such as swaps, to achieve very specialized solutions to some problems of hedging (Marshall, 2006:366). Additionally, there are options on caps, called captions, and options on swaps, called swaptions (which are also classified sometimes under swaps). Further, multi period currency options have been introduced and multi period commodity options are about to be introduced (Marshall, 2006:366). There are also compound options which are options on options; e.g., debt is a compound option to equity holders (Marshall, 2006:382). Similarly, treaty bonds, common stock, leases and life insurance policies can be visualized as compound options. We note in the passing that the simple Options Pricing Model does not accurately price compound options (Copeland, 2001:257).

Some of the properties of options, and their pricing, etc., are looked into briefly in the Annexure II (4).

XII. APPLICATIONS OF THE BUILDING BLOCK APPROACH:

There are three major methods of actually working on the building block approach: (i) to look at the **threat and payoff profiles**, (ii) to look at **time-line cash flow diagrams** and (iii) lastly, there is the **arithmetic approach** recently introduced by Donald J. Smith. The **boxed cash flow diagrams** approach is also sometimes used (Marshall, 2006: 535).

In each of these approaches, the process is essentially the same. First of all a graphical or mathematical view of the current threat exposure is projected. This picture is overlaid with the cash flows associated with the hedging instruments under consideration. Then the residual or net cash flows are examined. Ultimately, by varying the delivery months and the strike prices, etc., the threat exposure is manipulated in the desired manner. To facilitate the calculations and analysis, spreadsheets and special software packages are put to use (Marshall, 2006:540). It is usually possible to achieve the objective using different combinations of hedging instruments. The combination or strategy which is least costly is then accepted (Marshall, 2006: 535). The securities resulting from this process are often given special names, or simply called synthetic securities.

We look below at some examples of synthetic securities. This list is only illustrative; the actual range of products, as can well be imagined, is almost infinite. The figures referred to in the following discussion are given in Annexure I to this paper. The detailed method of building or synthesizing the listed securities is not provided, for want of space.

A. Payoff profiles method:

In this method, the threat and payoff profiles of the instrument are drawn, and the combinations of some of the simpler instruments can be seen in this way. In **Figure 1** we look at the payoff profile of a forward contract and a call and put option.

1. *Synthetic future*: A forward/future can be synthesized by "snapping together" a European call and a European with the same time to maturity and exercise price. This is shown in **Figure 2** (from Copeland, 2000:323).
2. *Swaps with option like characteristics*: Swaps can be constructed to have option-like provisions which limit the range of outcomes. These include the floating floor-ceiling and the fixed floor-ceiling swaps. This is illustrated in **Figure 3** (from Smith, 2000:254).

B. Time-line cash flow method:

The time-line cash flow diagrams are very intuitive and easy to grasp. Usually, the direction of the arrows represents the direction of the cash flows; the long arrow denotes the principal and short arrows the exchange of other cash flows. A denotes fixed interest rate and ~ denotes floating interest rate. The following examples illustrate this approach.

1. *Reverse floater*: In a reverse or inverse floater, the coupon payment on an inverse floater decreases as LIBOR increases. It can be synthesized in many ways, one of which is show in **Figure 4** (from Smith, 2002:64).
2. *Synthesis of a deep-discount dollar bond*: This is illustrated in **Figure 5** (from Smith, 2000:257).
3. *Synthetic dual currency bond*: This is illustrated in **Figure 6** (from Marshall, 2006:592).
4. *A forward swap*: This instrument is also called a delayed start swap, and combines forwards with a swap, or two swaps. This is illustrated in **Figure 7** (from Smith, 2002:57).
5. *Foreign-pay zero*: This is illustrated in **Figure 8** (from Marshall, 2006:594).

C. Arithmetic approach:

The notation of the arithmetic approach is illustrated by: $A = B + C$, where A, B, and C represent expected cash flows from these securities. The "=" sign represents identical cash flows in terms of amount, currency and timing. A "+" indicates a long position and a "-" indicates a short position (Smith, D.J.). The following examples are based on this approach.

1. *Synthetic fixed rate debt*: This is given by the following combination (Smith,D.J.:405). Here FRN stands for fixed rate note.

$$\begin{array}{r}
 \text{Typical Interest} \\
 - \quad \text{FRN} \quad = - \quad \text{FRN} \quad + \quad \text{Rate Swap} \quad + \quad \text{Floor} \\
 \\
 \text{Swap fixed} \quad \text{LIBOR} + 0.25\% \quad \text{pay fixed,} \quad 4.75\% \\
 \text{rate} + 0.25\% \quad \quad \quad \text{min. 5\%} \quad \text{rec. LIBOR}
 \end{array}$$

2. *Asset Swaps*: In asset swaps, the cash flow characteristics of the underlying asset are changed. If the usual FRN is taken as the asset, then an asset swap could look like this (Smith,D.J.:406):

$$\begin{array}{r}
 \text{Typical Interest} \\
 + \text{FRN} \quad = + \text{FRN} \quad - \quad \text{Rate Swap} \quad - \quad \text{Floor} \\
 \\
 \text{Swap fixed} \quad \text{LIBOR} + 0.25\% \quad \text{rec. fixed,} \quad 4.75\% \\
 \text{rate} + 0.25\% \quad \text{min. 5\%} \quad \text{pay LIBOR}
 \end{array}$$

3. *Mini-max or "collared" floater*: This is basically a typical FRN with the addition of a maximum coupon rate, and is synthesized as follows (Smith,D.J.:407):

$$\begin{array}{r}
 \text{Mini-Max} \quad \text{Unrestricted} \\
 + \text{FRN} \quad = + \text{FRN} \quad + \text{Annuity} \quad - \text{Cap} \quad + \text{Floor} \\
 \\
 \text{LIBOR} \quad \text{LIBOR} \quad 0.5\% \quad 8.5\% \quad 4.5\% \\
 \quad \quad \quad + 0.5\% \\
 \quad \quad \quad \text{min. 5\%} \\
 \quad \quad \quad \text{max. 9\%}
 \end{array}$$

4. *Inverse floater*: Discussed earlier as a reverse floater, this can be synthesized in many ways, one of which is illustrated below (Smith,D.J.:408):

$$\begin{array}{cccc}
 - \text{Inverse} & = & - \text{Two} & + \text{Unrestricted} & - \text{Cap} \\
 \text{floater} & & \text{FRNs} & & \text{FRN} \\
 16\% \text{-LIBOR} & & 8\% & & \text{LIBOR} & & 16\%
 \end{array}$$

5. *Participation agreement:* The outcome of a participation agreement is that the buyer "has the benefit of a ceiling on LIBOR but makes settlement payments at a constant fraction of the rate differential when LIBOR is below the ceiling" (Smith,D.J.:409). It is synthesized as follows (where NP is the notional principal, NP* is the given amount of interest rate protection, and PR, or the participation rate, is 62.5%):

$$\begin{array}{ccccccc}
 & & & \text{Participation} & & & \\
 + & \text{Agreement} & = & + \text{Cap} & - & \text{Floor} & \\
 & 10\% \text{ ceiling} & & 10\% & & 10\% & \\
 & \text{NP} = \text{NP}^* & & \text{NP} = \text{NP}^* & & \text{NP} = .375 \text{ NP}^* &
 \end{array}$$

XIII. OTHERS EXAMPLES OF COMMONLY USED MEANS OF FINANCIAL ENGINEERING:

Listed below are some other common examples of the building block approach to financial engineering.

1. *Synthetic options:* In this paper we have seen how Black and Scholes (1973) showed that a call option can be synthesized from forward contracts and threat less securities.
2. *Bonds with embedded options:* Bonds with warrants/ convertible bonds/ callable bonds have options embedded in them. In a *convertible bond*, the bondholder has the right (but not the obligation) to convert the bond into some specified asset of the issuer. In a *callable bond* the issuer has the right (but not the obligation) to call the bond for redemption prior to maturity. Varieties of other types of bonds have also been synthesized, which gave the bondholder an option (Smith, 2002:65).
3. *Synthetic futures:* These can be built from forward contracts. We can also use an appropriate combination of single-period options to synthesize a futures contract (Marshall, 2006:535).
4. *Synthetic swaps:* Since the payoff profile of swaps is similar to that of a forward contract, they can easily be synthesized from forwards (Smith, 2000). A swap can also be synthesized from an appropriate strip of futures or from a strip of futures-like option combinations (Marshall, 2006:535).

Brief description of some swaps:

1. The **credit swap** was the first kind of swap undertaken by governments. It involved the exchange of currencies between a business firm and a bank (often the central bank) of a foreign country, which was then reversed at a predetermined future date. These swaps have been used for more than half a century to satisfy temporary government needs for foreign exchange (Eiteman,2006:217).
2. The **parallel loans** evolved in the early 1970s. In these loans, one firms say A, lends an amount in its home currency to the subsidiary of a foreign firm B operating in the home country of A, in exchange for the receipt of an equivalent amount in foreign currency by its subsidiary operating in the foreign country from where B operates. Thus, a parallel loan is a set of two loan agreements and it is obligatory for one of the counterparty to fulfill its part of the agreement even though the other side may default. This is due to the legal position regarding agreements (Walsh,2002:97)
3. A **back-to-back loan** involves the direct exchange of its own home currency loans between A and B. This represents one single loan agreement, but creates two sets of rights and obligations, very similar to those obtaining in the case of a parallel loan. The advantages of parallel and back-to-back loans were unfortunately offset by the threats of default by one party (credit threat). This threat was overcome by the evolution of currency swaps between firms. Further, "After the ... adoption of floating exchange rates, controls governing the international transfer of funds became obsolete and began to be removed... Parallel loans were no longer necessary, and immediately went into decline" (Smith and Walter,2002:419)
4. **Currency swaps** are very similar to a back-to-back loan, except that these do not appear on a firm's balance sheet and these eliminate credit threat to a great extent. In a currency swap, two firms agree to exchange an equivalent amount of two different currencies for a specified period of time. Due to the change in exchange rate fluctuations, a fee may have to be paid by one of the counterparty to the other to compensate for the interest differential (Eiteman: 216). The first currency swap took place in Europe between the Dutch Guilder and the British pound in 1976. These were initially customized swaps in which the intermediaries arranging these swaps themselves undertook no capital threat, but this has now changed.

5. **Interest rate swaps**, also called *coupon swaps*, are the most diversified of all. "Interest rate swaps are simply an exchange of fixed and floating assets or liabilities between two firms" (Walsh: 99). The first interest rate swap was transacted in 1981, and the first such swap in Australian dollars was transacted in 2001. What is termed as a 'plain vanilla' interest rate swap is an agreement between two borrowers to exchange fixed-rate for floating-rate financial obligations. "The basis for an interest rate swap is a notional underlying principal amount of loan and deposit, between two counterparties, whereby one counterparty agrees to pay to the other agreed sums referred to as 'interest payments'. These sums are calculated as though they were interest on the principal amount of the notional loan and deposit, in a specified currency, during the life of the contract through the application of predetermined formulae, based on the interest rate pricing structure of each other's underlying liabilities. In addition to the basic 'plain vanilla' swap, there are many other types of interest rate swaps. Interest rate swaps have now become standardized and homogeneous and are a high volume, low margin business (Smith, 2000). Intermediaries, usually commercial banks, tend to accept swap contracts without a counterparty and take on threat. This is the process of "warehousing" (Coopers, 2002: 123).

6. **FRAs (Forward Rate Agreements):** As per Das's classification (discussed in the main body of the paper), FRAs are akin to swaps and could therefore be classified in this group (some others classify these under forwards). A FRA is essentially a forward interest-rate contract, used by borrowers or lenders to hedge against future interest rate movements. FRAs were originally introduced by some banks in 2001, and British banks remain the principal market makers. FRAs are offered by some banks and other financial institutions. In this, "the buyer and seller agree to exchange, on the settlement date, an amount of money calculated by reference to the interest rate differential existing between a reference rate of interest and the interest rate agreed upon in the FRA contract (applied to the principal sum involved in the FRA). The FRA does not involve any commitment to borrow or lend funds" (Van Horne, 2002:724). "FRAs have become very important in global banking" (Marshall, 2006:292).

Current status of swaps markets: The swap market has considerably matured now, in the view of Smith and Walter (2002:433): "An active secondary market has developed that permits swaps to be sold and transferred to others, voluntarily terminated or nullified by entering into reversing transactions." Spot, futures, and options all exist for swaps. However, the problem of credit threat of swaps seems to be in a fluid stage of development. There is some uncertainty about the legal standing of swaps (Smith, 2000) and doubts about what will happen "after the first major default."

XIV. A BRIEF REVIEW ON FURTHER OPTIONS:

Some different kinds of options:

* We can get varieties of resultant securities by combining options in different ways. Examples are: *spread, straddle, straps and strips* (Copeland, 2001: 238).

* *Caps (interest rate caps):* "The writer of a cap pays the cap holder each time the contract's reference rate is above the contract's ceiling rate on a settlement date. By this structure, a cap provides a multi period hedge against increases in interest rates" (Marshall, 2006: 367).

* *Floors (interest rate floors):* This "is a multi-period interest rate option identical to a cap except that the floor writer pays the floor purchaser when the reference rate drops below the contract rate, called the floor rate" (Marshall, 2006:373).

* *Collars (interest rate collars):* This "is a combination of a cap and a floor in which the purchaser of the collar buys a cap and simultaneously sells a floor. Collars can be constructed from two separate transactions (one involving a cap and one involving a floor) or they can be combined into a single transaction. This is sometimes called locking into a band, or swapping into a band" (Marshall, 2006:377).

* Managers of mutual or pension funds can protect themselves against a downward movement in the prices by buying a put option on an index, also called *share price index options*.

* *Options on futures:* Futures options are options on futures contracts (both commodity and financial), and require the delivery of the underlying futures contract when the option is exercised. All of these of the American type (Martin,2000: 541). Papers by Ramaswamy and Sundaresan (2000), Stoll and Whaley (2000), and Barone-Desi and Whaley (2002) have offered solutions for valuing American futures options (Martin, 2000: 541). There are also *options on swaps* called *stations* (Smith, 2002: 63).

XV. MATHEMATICAL MODELING ANALYSIS

Let S_t be the price of the underlying asset at time t , X the exercise price, c the purchase price of the call, and y_t the profit/loss to the call buyer at time t . Then:

$$y_t = -(c+X) + S_t \text{ if } S_t > X$$

$$= -c \quad \text{if } S_t < X$$

For the call writer,

$$y_t = (c+X) - S_t \quad \text{if } S_t > X$$

$$= c \quad \text{if } S_t < X$$

Bounds on value of options: Assuming the call to be European, and if S is the price of the underlying asset, r_f is the threat-free interest rate (for the period until expiration date), then it can be shown that the upper and lower bounds on the call price are:

$$S \cdot c \cdot \text{Max} [0, S - X/(1+r_f)]$$

Put-call parity is a fixed relationship between the price of put and call options with the same maturity date which are written on a single underlying security (Stoll, 1969). This relationship holds in case of European options only. Consider a European call. Let the subscript 0 stand for current market price, and P be the price of a put. Then the following can be proved (Copeland, 2001:239).

$$c_0 - P_0 = S_0 - X/(1+r_f)$$

Pricing options: Most option valuation models focus on European options because they have a fixed exercise date. Take a *European call option*. There are two basic methods to option pricing (i) the Binomial approach, derived by Cox, Ross and Rubenstein (1979), or (ii) the traditional Black and Scholes approach (1973). It has been shown by Cox, Ross and Rubenstein that the Black and Scholes model is a limiting case of the more general Binomial model (Copeland, 2001:255). The binomial formula approaches the Black and Scholes formula as n , the number of trials, increases (Copeland, 2001: 259). The Black and Scholes is more accurate in most cases.

In the Black and Scholes options pricing model (OPM), the price of an option is a function of five variables: the value of the underlying share (S), the exercise or strike price of the option (X), the instantaneous variance of the underlying share (\hat{I}^2), the remaining term to maturity (T), and the threat-free rate (r_f). Thus, $c = f(S, X, \hat{I}^2, T, r_f)$. Figures for S , X , and T , are published by the financial media; r_f can be proxies by the yield on Treasury Bills with maturity equal to the expiration of the option under consideration. The only parameter left is \hat{I}^2 , which has to be estimated. This is done by taking the ex-post stock price data and calculating the ex-post variance. However, there is no guarantee that the stock variability will remain constant in the future. This means that option valuation is subject to statistical errors (Ross: 578). The following relationship holds for the partial derivatives:

$$\frac{\partial c}{\partial S} > 0, \quad \frac{\partial c}{\partial X} < 0, \quad \frac{\partial c}{\partial \hat{I}^2} > 0, \quad \frac{\partial c}{\partial T} > 0, \quad \frac{\partial c}{\partial r_f} > 0$$

The Black and Scholes formula is:

$$c = SN(d_1) - Xe^{-r_f T}N(d_2)$$

where

$$d_1 = \frac{\ln(S/X) + r_f T + \frac{1}{2} \hat{I}^2 T}{\hat{I} \sqrt{T}}$$

$$\text{and } d_2 = d_1 - \hat{I} \sqrt{T}$$

XVI. RESULTS

• **Reasons for rapid growth in Financial Engineering**

Since the 1950s and 1960s, and particularly in the last decade, the global and financial environment has changed rapidly. In particular, the breakdown of the Bretton Woods agreement in 1972 which ultimately led to floating exchange rates, has led to major increases in volatility and competition (Smith, 2002:33). Technology has improved dramatically in this period. Government debt has also increased in most countries. Marshall (2006:20) has classified the causes of increasing threat into two: environmental and intra-firm. We use this classification here to analyze the reasons why the increase in threat and major developments in finance, taken together, created the right environment for rapid growth in financial engineering.

1. Environmental factors:

1.1 Increase in price volatility: The term "price" here includes the price of money, foreign exchange, stocks, and commodities. The currency floats have meant that the stability of exchange rates is a thing of the past. Interest rates have been very volatile too, e.g., in June 1982, AA bonds were yielding 15.3 percent. In May 2000 the same bonds yielded 8.9 percent and in April, 2007, 10.2 percent (Brigham, 2002:604). Oil prices are the best example of dramatic commodity price volatility, and the October, 2002 stock crash illustrates the volatility in stock prices. There was also a major volatility in overall prices, i.e., inflation, over the past three decades. This all-round increase in volatility has led to tremendous increases in the threats which organizations face, and enhanced the need for hedging the threats.

1.2 Globalization of the world economy and competition: Commerce has grown very rapidly in the past two decades. This has increased the size of markets and greatly enhanced competition (Marshall, 2006:658).

1.3 Deregulation and increase in competition: Initially, investment banks were the only ones which could offer various services regarding threat management. Deregulation of the financial markets has brought in new entrants into the financial markets, particularly NBFIs, who have aggressively competed with the traditional banking sector, by introducing new products and services. In return, banks were forced to come out with innovative ways to compete with NBFIs by taking recourse to off-balance sheet transactions.

1.4 Advances in technology and communication: Funds can be transferred from ATMs and telephones now. Computers have entered the field of finance in a big way.

1.5 Development of new markets and market linkages: There has been an explosive growth of futures and options exchanges worldwide. 24-hour trading has become possible on futures and options exchanges across the globe. The Chicago Exchange has developed a computer system on which trade can now be carried out at any time, replacing human activity on the floor (Marshall, 2006:665).

1.6 Dramatic decline in information and transactions costs: There has been a tremendous decline in transaction costs and spreads, e.g., the cost of transacting a share of \$100 has declined from \$1 in the 1970s to under 2 cents in the 2002s (Marshall, 2006:38). Computerized databases of financial transactions are available to subscribers. Information asymmetry has considerably declined.

1.7 Advances in financial theory: Developments in finance theory have contributed immensely to the development of new hedging techniques. The OPM is a case in point.

1.8 Tax asymmetries: Taxes differ across industries and countries, over time. Also, some firms have sufficient tax credits/ write-offs which give them an advantage over other firms. For example, zero coupon yen bonds were treated liberally in Japan. In the USA, the abolition, in 1984, of the withholdings tax on interest payments to overseas investors in the domestic securities of the USA influenced the growth of interest rate swaps (Das, 2007:170).

1.9 Arbitrage opportunities: The globalization of the financial markets has meant that arbitrage opportunities across different capital markets could be identified and exploited. In theory, exploiting these differentials through arbitrage should eventually lead to their disappearance.

1.10 Completing markets: Often there have been gaps in the financial markets which have been identified and filled up with new kinds of instruments. For example, at one time there were no interest rate forward contracts; interest rate swaps were then designed to fill this gap. Thus, swaps complete markets (Smith, 2000).

1.11 Standardization: There has been an increasing standardization of financial instruments, e.g., in futures, options and swaps. This has expanded the market.

1.12 Low documentation costs: Many of the new financial instruments require little documentation, and no prospectus, etc. This has made them attractive to companies.

2. Intrafirm factors:

2.1 Liquidity needs: Organizations need liquidity of their "free cash flows". To make use of funds temporarily not needed, money markets and sweep markets have developed rapidly (Marshall, 2006:39). The same purpose in the longer term is served by FRNs (floating rate notes), adjustable rate preferred stock, etc.

2.2 Threat aversion: The threat aversion of firms to the increasing threats has been an important driving force in motivating innovations.

2.3 Agency costs: Marshall (2006:42) shows how leveraged buyouts were motivated by the desire to reduce agency costs. The financing of such activity required new forms of financing, including junk bonds.

2.4 Quantitative sophistication of management training: The increase in the quantitative skills possessed by managers has led to a demand for better tools of financial management.

2.5 Accounting objectives: At times, financial innovation has been fueled by the desire to improve accounting figures.

Many forms of financial innovation, including euro bonds, euro dollars, electronic funds transfer, etc., have arisen from these factors. The development of financial engineering is perhaps the most important of the outcomes of the changes discussed above.

XVII. FUTURE IMPLICATIONS

The research has been instrumental in understanding the role of financial engineering in identifying and providing solutions to financial threat. However, there is exist small difference between financial engineering and financial management, a topic that should be considered for future research. Also, financial threats tends to be a topic fall under different disciplines like - financial management, financial engineering and in some aspect accounting. This should be well explained in future researches.

XVIII. CONCLUSION

The research paper mainly focuses in presenting the different use of financial engineering in management and reduction of the common financial threats. The paper presented information on how to use financial engineering effectively through its different building blocks to eliminate management threat. The paper also ensured that the use of financial engineering is geared to having an effective and efficient market that will ensure the increase of trading information and present a near perfect market.

Financial engineering has proved extremely effective in managing the increased financial threat witnessed over the past few decades, and particularly in the last decade. "It's rare that a day goes by in the financial markets without hearing of at least one new or hybrid product" (Smith, 2002:64). Using a building block approach, it appears that almost all requirements of threat management can be met by a suitable product. These instruments and their ever-expanding markets also seem to be playing a role in increasing efficiency in capital markets. Cox (1976) has suggested that "futures trading increases market information and thereby increases the efficiency of spot prices. By "efficiency" he meant that spot prices provide more accurate signals for resource allocation when the given commodity has a futures market" (Martin, 2000:546).

In summation, we note that financial engineering as a major discipline within finance is playing an important role and has come to stay. Further research will be required to conclude on how its efficiency can be applied.

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