

# Historical Review of Financial Engineering in the Financial Service Industry\*

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## Abstract

This paper historically reviews the financial engineering which is rapidly growing in financial industry over the world. Over the past two decades, financial field has been rapidly brought revolutionary changes in financial instruments, financial innovations and processes as well as applied mathematics. Due to the deregulation of the financial services industry in recent time, new financial products to meet the need of the financial customers are required. Thus new design of financial product has to be made in financial industry. Therefore, the role of financial engineering which provides the customer oriented product is an important contribution. I expect that this review of financial engineering will be big contribution in future developments and applications of many financial fields and even applied mathematics.

I think that new financial product and market design, improved computer and telecommunications technology that advances in the financial engineering field during the past quarter-century have led to dramatic and rapid changes in the structure of global financial markets and institutions. The scientific breakthroughs in financial engineering were shaped by the extraordinary flow of financial innovation, which coincided with those changes. I find that the cumulative impact has significantly affected all of us-as users, producers, or overseers of the financial system. Indeed, in providing the means for pricing and risk measurement of derivative securities, finance engineering has contributed fundamentally to the remarkable rate of globalization of the financial system. Financial engineers who designed derivative securities to function as adapters made this possible in large part. In general, the flexibility created by the widespread use of derivatives as well as specialized institutional designs provided as effective offset to

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dysfunctional country specific institutional rigidities. Financial innovation is a central force driving the financial system toward greater economic efficiency with considerable economic benefit having accrued from the changes over the past several decades. Mostly people suggest that financial innovations can be grouped as new products, new services, new production processes, and new organizational form. I document that factors for financial innovation are volatile financial environment due to inflation, technology, changes in the regulatory environment, and changes in perceived market conditions.

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〈Key Words〉 Financial Engineering, Applied Mathematics, Financial Innovation, Financial Instruments

## I . Introduction

Over two past decades, financial engineering has been dramatically growing field due to the deregulation of finance industry and often crisis of finance system of country and even rapidly growing new desire of finance customers. To provide these needs, financial engineering plays a key role in serving various types of needs. However, I think that rare paper provides the new sight to financial engineering even though new financial knowledge is required to understand and design the new financial products in these needs.

Financial engineering is the lifeblood of financial innovation. Actually financial innovation is the process that seeks to adapt existing financial instruments and to develop new ones so as to enable financial market participants to cope more effectively with the changing world in which we live. In addition, financial engineering also captures the spirit of financial innovation and adequately explains it. Its rich harvest over the past two decades has long been overdue. The extremely diverse nature of financial engineering, the rapid pace of change and new development, as well as the day-to-day pressures of business make it virtually impossible for any one professional to accomplish the task of researching and preparing a financial engineering scope.

Marshall and Bansal(1992) say that the rapidity with which corporate finance, bank finance, and investment finance have changed in recently years has given birth to a new discipline that has come to be known as financial engineering. As with most disciplines in their early stages of development, the field of financial engineering has attracted people with an assortment of backgrounds and perspectives. Financial innovations has included amazing advances in financial theory, computational capability, new product design, new trading processes, new markets, and new applications. In fact, it is known that each of these innovations has supported and reinforced the others. In the early 1990s, practitioners and academics alike began to recognize that this spate of innovation was not just a passing fad. Rather, something fundamental had changed. Indeed, something has, and the new profession known as financial engineering emerged(Beder and Marshall 2011).

Koo and Song(2012) argue that there are some connection between

mathematics and probability in history of finance. Financial engineering may be broadly defined as the development and creative application of innovative financial technology. It involves the design, the development, and the implementation of innovative financial instruments and processes, and the formulation of creative solutions to problems in finance. The term "innovative" is used here to describe a solution that is non-trivial.

Finnerty(1988) documents that innovative financial solution may involve a new consumer-type financial instrument, such as IRA and Keogh accounts, a new security, such as money market preferred stock; a new process, such as the shelf registration process; or a creative solution to a corporate finance problem, such as the design of customized security arrangements for a project financing or a leveraged buyout.

In domestic context, Cho, Lee, and Kang(2012), Kim and Lee(2011), Kim(2011), and Koo, Lee, and Seo(2011) provide just historical review of insurance and asset allocation system. They just find the roles of one side financial system related to insurance and operation of asset.

Financial technology includes financial theory, quantitative techniques, financial products, and financial processes. At a microeconomic level, the motivation behind financial engineering is to produce profits for the innovators by finding better ways to address society's needs. At a macroeconomic level, financial engineering helps improve the allocation of any economic system. Indeed, financial engineering epitomizes Joseph Schumpeter's view of capitalism as "creative destruction." New products replace old products, new theory improves on old theory, and new processes supplant old processes(Beder and Marshall 2011).

Financial engineering borrows heavily and liberally from other disciplines, which helps explain why the field has attracted people from across the scientific spectrum. The key to understanding financial engineering is understanding innovation in all of its dimensions and turning this innovation into practical solutions. While, in some sense, financial engineering has been with us since the innovation of money, financial engineering has not, until quite recently, been recognized as a profession. What has changed, more than anything else, is the pace of innovations.

This paper reviews historical financial engineering. That is, it overviews the financial innovation and innovative new products related to financial engineering.

The remaining section is as follows. Section 2 explains the history of financial engineering and time trend in it. Section 3 reviews the financial innovation and products related to financial engineering. Last section provides the conclusion and summary.

## II. Historical Overview of Financial Engineering

Financial engineering has been recent interesting topic and attracts people to study on financial innovation. Let's go back to history. Markets and some financial functions have been around for thousands of years. For instance, there is some evidence that the Romans may have invented checking as early as 352(B.C). By the year 1750, the basic financial firms were established to take deposits and make loans and write insurance and provide investments(savings and pension products) and intermediate(checking, crossing trades, brokering) and underwrite and distribute and facilitate trade. It is acknowledged that from the 1700s until about 1970(more than 200 years), the development of financial firms was continuous and done at a manageable pace. But the period was also one of frequent violent upheaval, as wars repeatedly ravaged nations and populations. New financial firms were born and others went out of business, but the basic functions of banks, insurance companies, asset managers, company pension funds, central banks, brokers, and dealers did not change radically. Most firms had monoline business models, and the primary business was the intermediation of capital.

Table 1 summarizes the financial engineering time line. As shown in Table 1, it shows that the pace of innovation was slow, but there were notable developments in the four decades leading up to the inception of financial engineering. Harry Markowitz published his seminal work on portfolio theory in the 1950s and the first eurobonds were issued in the early 1960s, and certificates of deposit were introduced in the late 1960s. History of finance shows that there were advancements in technology, but most were not broad-based consumer

products. Chester Carlson invented xerography(photocopying) in 1938 and the first computer(the ENIAC) was unveiled in the 1940s. Also Bell Systems revealed the transistor that would revolutionize telecommunications in 1947.

〈Table 1〉 Summary of financial engineering time line

Time Line	Contents
Inception and early stages: (1970- 1997)	<ul style="list-style-type: none"> <li>• Deregulation of interest rates, currencies, and commodity prices creates need to manage risks.</li> <li>• Tools created to do so (derivatives, theoretical pricing models, risk measures).</li> <li>• Technology provides platform and derives globalization (telecom advances, hardware, software, first PCs)</li> <li>• Financial firms build businesses to intermediate risk in addition to capital.</li> </ul>
Massive growth: (1998-2006)	<ul style="list-style-type: none"> <li>• The world of "monoline" financial firms ends as banks, insurers, traditional, and alternative asset managers.</li> <li>• Asian currency crisis, Russian crisis, and LTCM launch global growth of the business of enterprise risk management.</li> <li>• Ongoing deregulation and freer markets spur growth.</li> <li>• Credit derivatives and securitization growth from zero into the hundreds of trillions, massively changing how risk and return are originated, held, and transferred.</li> <li>• BRICs, sovereign wealth funds emerge as major players in the world capital market, vastly fueling globalization.</li> <li>• Huge liquidity, low risk premiums, and low interest rates drive massive growth in the size of firms(from bank to hedge funds), capital markets(from emerging to established), and the use of leverage.</li> </ul>
Rationalization: (from 2007, ongoing)	<ul style="list-style-type: none"> <li>• Global financial markets melt down and continue in various states of disarray, starting with residential mortgages and progressing to commercial real estate, financial firms, corporate, municipal and sovereign risks.</li> <li>• Troubled assets and liquidity crises lead to trillions in bailouts and drive global de-leveraging and de-risking.</li> <li>• A dramatic "re-think" of the role of governments/greater regulation/need to manage systematic risk underway.</li> </ul>

Source: SBCC Group Inc.

Technology has been aggressively advanced and it has affected the huge impact on financial market. For example, the first modem enabling communication between machines was developed in the later 1950s and the National Aeronautics and Space Administration(NASA) launched the first communications satellite in 1962. As the 1960s ended, Texas Instruments developed the first handheld calculator, which retailed for \$ price of 2,000.

After World War I and II, this period was ever increasing financial market regulation. That is, this period included episodes of currency instability, devastating inflation in some countries. Substantial regulation was put in place to promote the safety and soundness of individual countries' financial system. Most regulations adopted were rule-based by category/type of firm versus by function. In addition, there were important agreements made between countries. For example, fixed exchange rates and interest rates with cap were implemented. Hence, there was little price volatility to manage. However, toward the end of the period, glimmers of deregulation and technology advances laid the groundwork for the beginning of financial engineering.

Based on advance in this technology, I describe the historical stage for financial engineering in following section classified by inception and early stages, the massive growth period, and the rationalization period as shown in Table 1.

### **III. Inception and the Early Stages (1970-1997)**

During the latter part of the twentieth century, four forces worked together to drive the separation between the past and the present businesses of financial service industry, such as technology, globalization, deregulation, and risk intermediation.

First of all, I describe the technology impact on financial system. By 1970 the business of financial firms had begun to change radically and irrevocably. Banks, insurance companies, funds, central banks, brokers, dealers, government entities, and others faced difficult new risks and challenges to their profitability. As shown in Table 2, I summarize these facts faced by financial firms.

As shown in Table 2, interest rates and currencies were deregulated, and the

OPEC was established. Increasingly, global corporations struggled as well to manage their income statements, balance sheets, and raw material costs.

Technology was the first force. Until the advent of personal computers and parallel processing in the 1980s, it is recognized that most technology was too slow to be utilized in the context of the capital markets. Before the advances in technology, mathematical techniques long used in the sciences could only be used theoretically in finance due to the inability to wait hours or days for answers. As this period progressed, many techniques whose power was only dreamed about in the early 1900s became employable practically by dealers, end users, regulators, and others. This created not only greater opportunities to see both risk and reward, but also a shortened cycle of innovation.

Globalization was the second force. Information flow became cheap and virtually instantaneous and cross-border transactions were executed in seconds versus days at the beginning of the period with technology arrived e-mail and satellite communications.

Deregulation was the third force. In 1971, the Bretton Woods system, which, through government intervention, had worked remarkably well in maintaining stable exchange rate since the end of World War II, collapsed. This was followed by a dramatic increase in the volatility of exchange rates. As this period began, Canada and Germany had begun interest rate deregulation. In 1980, the United States began a process of deregulating its savings, commercial, and investment banks. France deregulated many institutions in 1981, and Great Britain deregulated securities firms with the so-called Big Bang in 1986.

The fourth force was the expansion of financial institutions' business to include the intermediation of risk in addition to the intermediation of capital. No longer would monoline financial intermediaries handle all aspects of the borrowing and lending transaction. During this period, not just banks but mutual funds, insurance companies, brokers, government agencies and credit unions became ever more likely to stand in between, not only to move capital, but also to move risk from suppliers to users. Large world events further drove the need to manage risk.

In summary, during this phase, financial firms were very much in the business of responding to their own needs to manage risk and clients' needs to manage

risk. They created new products, notably derivatives, called-synthetics, and financially-engineered securities. During this period, the financial engineer was born and financial engineering became its own profession. Also during this period, it was no longer possible to distinguish financial institutions merely by their names. Central bank and national governments faced increasing difficulty in monitoring off-balance-sheet exposures and in resolving large-scale, cross-border financial problems such as the freezing of Iranian asset, BCCI, Barings, Olympia & York, and Lloyd's due to the lack of a uniform commercial code across nations.

#### **IV. Massive growth period**

In period of 1998 to 2006, the Asian financial crisis began with the financial collapse of Thailand's currency, the Thai baht. Currencies across Asia slumped at the same time that equity and other asset markets devalued. These events, in turn, caused a precipitous increase in borrowing. A slump in world commodity prices triggered a Russian financial crisis. A collapse of Russia's currency, bond, and equity markets followed.

These crises led to a new focus on enterprise risk management and the creation of the so-called "enterprise risk manager." I find that there also was rapid innovation in credit default swaps and currency swaps grew sixfold and credit default swaps grew hugely. During this period, the economic environment was one of remarkable stability and included flush liquidity, relatively low volatility, low interest rates, rising equity and real estate prices, and easy-to-obtain leverage. The capital markets absorbed several large market corrections, including substantial accounting scandals and the bursting of the tech bubble. During this period, the landscape of financial firms changed substantially.

Around the world, massive deregulation of financial firms commenced as the business models of investment banks, commercial banks, and broker-dealers converged with private equity, alternative asset management, and insurance. Several financial firms rode the wave of the massive derivatives and structured

products growth, and so joined the ranks of top derivatives and structured products behemoths, including UBS, ING, HBC, Barclays, Lehman Brothers, Merrill Lynch, Bear Stearns, and American International Group(AIG), among others.

Whereas hedge funds were almost exclusively based in the United States at the beginning of the period, hedge funds in Asia grew to \$110 billion, and in Europe to \$400 billion, by the end of 2006. Central banks and sovereign wealth funds in Asia and the Middle East accumulated an estimated \$7 trillion to \$10 trillion in assets, becoming increasing purchasers of U.S. debt and net suppliers of global capital.

Quantitative trading grew substantially, due to the success of Renaissance Technologies LLC and many commodity trading advisor(CTAs). G-7 investors massively increased their global presence, focusing particularly heavily on Brazil, Russia, India, and China(BRICs) and other emerging markets. The International Monetary Fund(IMF) had played a substantial role in the Asian and Russian financial crises, it was fighting for relevancy as the strong economic environment continued into 2006.

Also in this period, firm risk reporting added many new dimensions, especially to capture correlation risk. Further, value at risk(VaR), stress tests, and Monte Carlo simulations continued as day to day features of a best practice risk management program. A notable turning point came in 2007 with the subprime mortgage crisis from U.S. that exposed pervasive weaknesses in the measurement of risk, particularly with respect to how interconnected many institutions had become. Consequently, the debate about national and global financial re-regulation focused the spotlight on systemic risk.

## V. Rationalization period

This period is between 2007 and today. Expansionary monetary and fiscal policies, combined with substantial deregulation of capital markets and financial firms, had facilitated explosive growth in financial engineering. It is acknowledged that the beginning of the current financial crisis commonly is

linked to the United States' subprime mortgage defaults that began in earnest in 2007 while there were some signs of a weakening residential mortgage market in the United States in 2005, as well as weakening loan markets that had earlier fueled hugely appreciated assets in other countries.

Early in the crisis, a huge focus was placed on credit derivatives, securitization, high leverage, off-balance-sheet financing, and failures in specific and enterprise risk management. As the crisis continues to unfold, additional focus has been placed on pro-cyclical regulatory, accounting, and risk management practices, also, compensation practices have been placed under the spotlight as strong contributors to the global crisis. At the same time, the practical result has been de-risking and de-leveraging with global write-downs by banks at \$1.5 trillion at the end of 2009 and with IMF estimating in April 2010 that the global bank write-downs will reach \$2.3 trillion by the time the crisis is completely resolved. This is considerably more than banks raised in new capital during the same period. The substantial losses faced by investors in certain types of financially engineered credit instruments, and the incineration of trillions of dollars of value, have resulted in the nationalization of numerous financial firms and global companies plus staggering bailouts by governments around the world. It is found that some instruments are just beginning a likely write-down cycle while other instruments are well into their write-down cycle.

Financial engineering has been forced to enter a rationalization phase. We can think that most firms are in the process of re-viewing, re-thinking, and also re-tooling the procedures, policies, assumptions, and techniques underneath both their specific and enterprise risk management. In addition, regulators, supervisors, and legislators are in the process of conducting substantial reviews and hearings regarding systemic risk and existing regulatory frameworks. So they are conducting investigations into firms that failed or were nationalized. In this period, there were substantial regulatory change and risk innovation.

## **VI. Conclusion Remarks**

This paper describes the some historical fact about the financial engineering. I

find that there were huge change and financial innovation as well as financial instrument related to financial engineering field. We are sure that financial engineering helps explain and create the new financial instruments and protect the financial customer's needs from market downturn over the world. Therefore, we find that many innovations are progressing up to today and they provide the new instruments to various type of investors in financial markets.

After advance in financial engineering, the benefit is found in the equity market and debt market. New instrument products based on debt and equity are created and they also create new wealth in capital market and help financing to firm. To know these facts is very important to understand the financial market which provides the fund to all economic entities. Most investors acknowledge that these benefits are huge and also creative value.

본 논문은 다른 학술지 또는 간행물에 게재되었거나 게재 신청되지 않았음을 확인함.

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# 금융공학의 역사적 고찰\*

손 판 도\*\*

## 요 약

본 논문에서는 최근 전 세계적으로 급격하게 성장하고 있는 금융공학에 대한 일반적인 역사적 고찰을 목적으로 하고 있다. 과거 20년간 금융 분야는 금융도구, 금융혁신 뿐만 아니라 응용수학 분야에서도 혁명적인 변화를 가져오고 있다. 최근 금융서비스 산업의 탈규제화로 인하여 금융소비자들의 요구에 부합되는 새로운 금융상품이 요구되었다. 따라서 이러한 새로운 금융상품의 설계가 금융 산업에서 일어났다. 그러므로 금융 고객지향 상품을 제공하는 금융공학의 역할은 매우 중요한 공헌을 할 것으로 기대할 수 있다. 본 논문에서 금융공학에 대한 역사적 고찰은 미래 금융시장의 발전 및 응용 뿐만 아니라 응용수학 분야에서도 커다란 공헌을 기대할 수 있을 것으로 생각된다. 새로운 금융상품, 시장의 설계 및 향상된 컴퓨터 성능 및 통신기술의 발전은 금융공학 분야에서 지난 세기 동안 엄청난 발전 및 기여를 하였다. 이러한 변화로 인하여 세계적인 금융시장 및 금융기관들의 구조에도 급격한 변화가 동반되었다. 금융공학 분야에서 과학의 발전은 엄청난 금융혁신의 원동력이 되었다. 따라서 과거 많은 과학 발전이 결국 금융상품의 최종소비자들의 요구에 부합하는 결과를 가져왔고, 이러한 와중에 파생상품의 가격 결정 및 위험관리에 대한 수단을 제공하게 되었다. 이러한 금융혁신은 결국 금융공학 분야가 세계금융시스템을 건인할 원동력이 되었고, 금융공학이 금융소비자들에게 혁신적인 상품 및 설계를 제공하는 수단으로 인식된 것이다.

금융공학자는 많은 분야에서 파생상품에 대한 기능을 설계하며 무한한 가능성을 만들어 낼 수 있는 과학자로 인식되고 있다. 특히 파생상품을 통한 제품 유연성 및 특정 기관설계를 통한 제품 능력 향상은 각 기관 내에 존재하는 부기능을 효율적으로 제거할 수 있는 수단으로 사용될 수 있다. 금융혁신은 또한 보다 더 경제적 효율성을 증가시키는 촉매역할을 하며 이러한 금융혁신의 기본 바탕은 금융공학을 통하여 일어난다.

대부분의 사람들은 금융혁신이 새로운 상품, 새로운 서비스, 새로운 생산과정 및 새로운 조직구성으로 이루어져 있다고 믿고 있으며, 이러한 혁신적인 상품 개발은 결국 금융공학을 통하여 이루어진다는 것이다. 금융혁신의 요인들은 인플레이션에 기인된 변동성 있는 금융환경, 기술진보, 규제환경 변화 및 시장인식에 대한 변화 등으로 생각해 볼 수 있을 것이다. 따라서 이러한 환경변화는 금융시장 자체를 변화시키며 결국 투자

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자들 입장에서 보다 안전한 현금흐름 설계가 필요하게 된 것이다. 이러한 측면에서 금융공학은 새로운 설계 도구를 제공하며, 새로운 현금흐름을 창출할 수 있는 아이디어와 혁신적인 수단을 제공할 수 있을 것으로 기대한다.

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〈주요용어〉 금융공학, 응용수학, 금융혁신, 금융도구