

PART I

Overview

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March 24, 2011

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CHAPTER 1

The History of Financial Engineering from Inception to Today*

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WHAT IS FINANCIAL ENGINEERING?

Financial engineering may be broadly defined as the development and creative application of innovative financial technology. 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 scarce resources. Allocation of resources is the fundamental objective 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.

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 innovation.

The history of financial engineering is presented in the segments illustrated in Exhibit 1.1.

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Exhibit 1.1 Financial Engineering Time Line**Inception and Early Stages (1970–1997)**

- Deregulation of interest rates, currencies, and commodity prices creates need to manage risks.
- Tools created to do so (derivatives, theoretical pricing models, risk measures).
- Technology provides platform and drives globalization (telecom advances, hardware, software, first PCs).
- Financial firms build businesses to intermediate risk in addition to capital.

Rationalization (from 2007, ongoing)

- 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.
- Troubled assets and liquidity crises lead to trillions in bailouts and drive global de-leveraging and de-risking.
- A dramatic “re-think” of the role of governments/greater regulation/need to manage systemic risk underway.

Massive Growth (1998–2006)

- The world of “monoline” financial firms ends as banks, insurers, traditional, and alternative asset managers combine and enter each others’ businesses globally.
- Asian currency crisis, Russian crisis, and LTCM launch global growth of the business of enterprise risk management.
- Ongoing deregulation and freer markets spur growth.
- Credit derivatives and securitization grow from zero into the hundreds of trillions, massively changing how risk and return are originated, held, and transferred.
- BRICs, sovereign wealth funds emerge as major players in the world capital market, vastly fueling globalization.
- Huge liquidity, low risk premiums, and low interest rates drive massive growth in the size of firms (from banks to hedge funds), capital markets (from emerging to established), and the use of leverage.

Source: SBCC Group Inc.

WHY DIDN'T FINANCIAL ENGINEERING START SOONER?

Markets and some financial functions have been around for thousands of years. There is evidence, for example, 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; make loans; write insurance; provide investments (savings and pension products); intermediate (checking, crossing trades, brokering); underwrite; distribute; and facilitate trade. 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 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.

As summarized in Exhibit 1.1, 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; the first Eurobonds were issued in the early 1960s, and certificates of deposit were introduced in the late 1960s. There were advancements in technology, but most were not broad-based consumer products: Chester Carlson invented xerography (photocopying) in 1938; the first computer (the ENIAC) was unveiled in

the 1940s; Bell Systems revealed the transistor that would revolutionize telecommunications in 1947; the first modem enabling communication between machines was developed in the late 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 \$2,000.

The decades after World War I right through to the early 1970s were a period of ever-increasing financial market regulation. This period included episodes of currency instability, devastating inflation in some countries, the Great Depression, World War II, and the rebuilding of Europe and Japan in the wake of that global calamity. Substantial regulation was put in place to promote the safety and soundness of individual countries' financial systems. 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 were established between major countries at the Bretton Woods Conference of 1944. The interest rates paid by savings banks were capped. Commodity prices were kept artificially low by many governments. Hence, there was little price volatility to manage. Also of note is that fewer than 350 companies worldwide had assets in excess of US\$500 million, so most financial activities were local (within home countries) rather than global. Losses by financial firms during this era were either credit-based (for example, the failure of the Austrian bank Credit Anstalt that led to substantial overnight foreign exchange losses for counterparties) or operational-based (for example, the United States' paper crunch during which trading volume outstripped settlement capabilities, leading to the failure of 160 members of the New York Stock Exchange).

Toward the end of the period, glimmers of deregulation and technology advances laid the groundwork for the beginning of financial engineering.

INCEPTION AND THE EARLY STAGES (1970 TO 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 firms:

1. Technology
2. Globalization
3. Deregulation
4. Risk intermediation

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 summarized in Exhibit 1.2, interest rates and currencies were deregulated, and the Organization of Petroleum Exporting Countries (OPEC) was established—all leading to substantial new volatilities to manage. 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, most technology was too slow to be utilized in the

Exhibit 1.2 Early Stages (1970–1997)

Date	New Products/ Risk Innovations	Technology	Deregulation/ Regulatory Change	Key Milestones for Different Types of Financial Firms
1970–1975	EEC common exchange rates (snake).	The invention of the floppy disk provides the first source of portable storage of data (1970).	U.S. President Nixon ends Bretton Woods system and takes away gold standard, while still keeping fixed exchange rates (1971); by 1973, floating exchange system adopted globally.	State and federal deregulation of financial institutions initiated S&L institutions to engage in riskier investments in sectors such as real estate, construction, and services.
1970–1975	Early GAP analysis for banks & thrifts.	Intel introduces the world’s first single chip microprocessor (1971).	Oil shocks of 1970s: OPEC increased price of oil due to the devaluation of U.S. dollar—received less real income, and political conflicts in the Middle East at the time also spurred unpredictable changes in oil prices.	Multinational corporations were on the rise—7,000 parent companies by 1970; 333 had assets of at least \$500 million, and one-third of those corporations had assets of at least \$1 billion.
	Capital Asset Pricing Theory	NASDAQ began its operations as “the world’s first electronic stock market” (1971).	U.S. removed capital controls.	Government National Mortgage Association, or Ginnie Mae, introduces first mortgage pass-through securities (1970).
	The Black-Scholes model	The advent of the Monroe 1272, the first electronic bond yield calculator (1971).	Australia begins process of financial deregulation—continues on through to mid-1980s.	William Fouse and John McQuown created first index fund; today known as The Vanguard Group (1971).
	Prudent-person theory	First email program created by Ray Tomlinson of BBN Technologies (1972).	Commodity Futures Trading Commission Act (1974).	

Extension of portfolio theory to hedging with futures.	Employee Retirement Income Security Act (ERISA) provided pension fund rights for employees (1974).
Mortgage-backed bonds Chicago Board Options Exchange (CBOE) was opened for trading options on common stocks (1973). Floating rate notes (Euromarkets 1970, U.S. market 1974). Exchange-traded futures on interest rates and currencies (1972-1977). Puttable bonds (1976)	International Banking Act (1978)
European currency unit (1979)	Great Britain removes capital controls (1979).
1981-1985 Application of Macauley's duration (published in 1938).	The Depository Institutions Deregulation and Monetary Control Act (DIDMCA) of 1980 and Garn-St. Germain Depository Institutions Act of 1982 began process of bank deregulation by removing restrictions on real-estate loans and raising deposit insurance limits.
First supercomputer crafted by Seymour Cray (1976).	The decade of hostile takeovers and leveraged buyouts; easier to finance because of rise of Michael Milken's junk bond market.
IBM designs the modern computer ("PC" or "personal computer") (1981).	

(Continued)

Exhibit 1.2 (Continued)

Date	New Products/ Risk Innovations	Technology	Deregulation/ Regulatory Change	Key Milestones for Different Types of Financial Firms
	Equivalents	Hewlett-Packard introduces its HP 12c financial calculator, which eventually became a standard tool for financial professionals (1981).		Currency swaps first introduced when World Bank swapped dollars with IBM for IBM's excess Swiss francs and German marks (1981).
	Convexity	Microsoft Corporation launches the Windows© program—still predominant software used in finance (1985).		
	Sharpe ratio			
	The Greeks for options (delta, gamma, "vega," theta, rho).			
	Stress testing			
	Scenario analysis			
	Option-adjusted spread			
	Portfolio Insurance			
	Bonds with warrants			
	Municipal bonds with 7-day puts.			
	Silver-indexed bonds			
	Zero coupon bonds (1981)			
	Dual currency bonds (1981)			
	Swaps, caps (1981)			
	Stock index futures (1982)			
	Options on futures (1982)			
	Adjustable rate and money market preferred stock (1982–1984).			
	Collateralized mortgage obligations (1983).			

Risk-adjusted return on capital (1983).	Undertakings for Collective Investments in Transferable Securities (UCITS) (1985).	Tax Reform Act of 1986 prevented commercial banks from purchasing municipal securities.
Asset-backed securities (1985)	"Big Bang" reforms in U.K.: eliminating fixed commission system, allowed more foreign investment, and improved screen technology for trading.	Junk-bond market increased from \$10 billion in 1978 to \$189 billion 1989 (about 34% increase each year).
Inverse floaters (1986)	Lotus Notes is the first commercially released product that features document sharing and remote location communication, and becomes one of the most powerful web conferencing tools (1989).	Double-digit performance of Julian Robertson's Tiger Fund astounds the public and initiates great interest in hedge fund industry.
Limits on exposure by duration bucket (1986).	Basel I—provided minimum capital requirements for banks and introduced to members of the G-10 (1988).	Insurance companies began offering catastrophe bonds that are linked to major catastrophic, often natural-caused, events. Insurance companies transfer some of their risk obligations to investors.
Credit card receivable-backed securities (1987).	Financial Institutions Reform, Recovery and Enforcement Act (FIRREA) makes major regulation changes to savings and loan industry. (1989)	End of 1980s and beginning of 1990s, all European countries established derivatives exchanges—amount of derivatives outstanding increased from \$2.7 billion (1986) to \$2.4 trillion (2001)

(Continued)

Exhibit 1.2 (Continued)

Date	New Products/ Risk Innovations	Technology	Deregulation/ Regulatory Change	Key Milestones for Different Types of Financial Firms
	CBO/CLOs (1987)			Over \$80 billion of foreign investment in developing nations by multinational corporations.
	Principal exchange-rate-linked securities (1987).			Long-Term Capital Management formed in 1994; strategy concentrated on "convergence-arbitrage" trades, trying to profit from small price differences among similar securities; used very high leverage, ratio of 25:1.
	Swaptions (1988)			After Bill Clinton passed a law in 1995 that allowed easy access to bank credit, commercial banks began issuing large numbers of sub-prime mortgage loans.
1991-1996	Bonds with earthquake puts.	CNBC expands its broadcasting at an international scale with the launch of CNBC Asia. CNBC Europe begins its programming a year later (1995).	Japan begins process of financial deregulation.	

Credit default swaps—total-return swaps—credit-linked notes.
Palm, Inc. introduces the first successful handheld computer (also known as PDAs, or personal digital assistants), the Palm Pilot (1996).

CMT derivatives
Power structures
Energy derivatives

Commodity indexed notes (1991)
Structured notes (1991)

Path-dependent derivatives (1991–94)
Equity linked notes (1993)

Market risk, operational risk and other non-credit based reserves.

Value at Risk

M-squared

Multi-period and Monte Carlo methods for options models.

Sensitivity to model risk.

Portfolio allocation according to expenditure of risk.

Risk Metrics (1994)

Equity with litigation-output option.

Derivatives based on the Euro.

Inflation-linked US Treasuries (1996).

Act of God bonds (1996)

Balance sheet CLOs (1996)

context of the capital markets. Prior to 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.

Dramatic comparisons are evident—a list of *all* innovations in the early 1970s began to be matched by those in a single quarter. With the exceptions of commodity futures and currency and commodity forwards, derivatives markets that were nonexistent in 1970—for example, interest rate swaps and currency swaps—topped \$50 trillion outstanding by the end of 1998.¹ Structured notes, collateralized mortgage obligations (CMOs), and asset-backed securities (ABS) were all introduced. Advances in technology changed how firms and individuals participated in the capital markets. Transactions became ever less “hard copy and local” and ever more “electronic and global.” The contrasts make the beginning of this period sound like the Dark Ages: At the beginning of this period, we did not have the personal computer; instead, handwritten spreadsheets and calculators were used to perform calculations, and pools of typists painstakingly produced single documents on wide-carriage typewriters. We did not have desktop publishing; instead, typesetters placed lead type in individual rows, and many an all-nighter was spent proofreading the lines as they were changed. We did not have mortgage calculators to perform interest and principal calculations; instead, bankers looked up monthly payment amounts in books that contained tables of principal and interest for different rates.

Globalization was the second force. With technology arrived e-mail and satellite communications. Information flow became cheap and virtually instantaneous, and cross-border transactions were executed in seconds versus days at the beginning of the period. A related result was that capital market events began to transcend borders, sometimes causing sympathy crashes or other market moves as traders tried to anticipate one market’s reaction to another’s event. Yet another change was that financial firms began to shop the world’s markets for the best deal, not only for themselves but also for their customers. At the beginning of the period, a U.S. corporation looked to its lead bank or to the domestic debt and equity markets to raise capital, and it was rare to issue a Eurobond, a Samurai bond, or a Yankee bond. During this period, the list of capital-raising alternatives grew much longer, and it became standard to include the public and private European and Asian capital markets, as well as new financial lenders such as mutual funds. Often, new markets were used in combination with derivatives so that borrowers or investors could swap back or transform the currency or interest rate basis to a preferred structure. In addition, borrowers and investors alike began to use futures and over-the-counter derivatives, notably caps, collars, and floors, to alter the risk/return structures of assets and liabilities.

Deregulation was the third force. In 1971, the Bretton Woods system, which, through government intervention, had worked remarkably well in maintaining stable exchange rates 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 1979, Paul Volcker,

succumbing to the powerful forces of disintermediation brought on by inflation, freed short-term U.S. interest rates. Banks would now pay market-determined rates rather than government-mandated rates. In 1980, the United States began a process of deregulating its savings, commercial, and investment banks. France deregulated many financial institutions in 1981, and Great Britain deregulated securities firms with the so-called Big Bang in 1986. The oil shocks of the 1970s, and again later during the Gulf War, rather than being managed by governments, were left to market forces. As a result of deregulation and the other forces, the currency, interest rate, commodity, and stock markets experienced unprecedented volatility.

The fourth force was the expansion of financial institutions' businesses 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: For example, the historical volatility of oil had a high of about 30 percent but increased to 300 percent during the Gulf War. In other words, the likelihood that oil prices would change over a given period of time increased tenfold. Globalization and technology had enabled the proliferation of products to manage such risks: Analysis and computations previously untenable in a volatile environment had grown feasible. Financial firms stepped in to design and execute risk management products, not only to manage their own risks but also to service their customers.

The collapse of Bretton Woods (1971); the oil shocks (1973, 1979, and 1990); a major stock market crash (1987); and dramatic currency moves (notably the Japanese yen, Italian lira, and Mexican peso in the 1990s) made it clear to corporations and financial institutions that active risk management was essential to their financial health and competitiveness. Whereas it had been acceptable to most shareholders in 1970 for corporations to announce increased sales but decreased profits due to currency exchange losses or volatile raw materials costs, this was no longer the case by the end of the period. Shareholders demanded that corporations employ risk/reward management tools to keep risk within acceptable bounds.

The now-infamous savings and loan (S&L) crisis provides an excellent example of how the new products offered by financial firms could be used to better control risk. In the late 1960s the business of S&Ls was, essentially, as it had been since the emergence of these institutions in the United States after World War II. Simply stated, S&Ls invested short-term depositors' funds in long-term mortgage loans to homeowners. This asset-liability mismatch caused few problems while interest rates were low and stable. However, when interest rates rose, disintermediation became inevitable. A deregulation of interest rates in 1979 became a necessity for the United States to remain competitive in the new global playing field. As interest rates tripled to over 20 percent in 1979–1980, S&Ls had to raise rates paid on their deposits beyond those received on their existing mortgage loan portfolios, creating huge losses that the industry could not sustain. A government bailout resulted, and the need for greater risk management was clear. By the end of this period,

simple interest rate swaps, one of the most common risk management products today, and engineered securities in the form of CMOs and structured deposits, assisted S&Ls in managing their risks profitably.

The interaction of these forces was at many times painful but also helpful to financial firms and corporations. On the painful side, at the same time that many financial firms struggled with default crises in less-developed country debt, high-yield debt, and commercial real estate, deregulation reduced profits or produced negative profit margins. On the helpful side, many new innovative products, markets, and delivery channels opened to financial institutions through technology and others' deregulation. In addition, the need to manage increased volatility, combined with the ability to deploy technology within the time frame of traded markets, provided the means to create new multitrillion-dollar markets such as risk advisory services, derivatives, and financially engineered securities, which bolstered profits and risk management capabilities at a critical time.

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 (at first called "synthetics") and financially-engineered securities. They added risk intermediation to the business of capital intermediation. During this period, the financial engineer was born and financial engineering became its own profession. Organizations such as the International Association of Financial Engineers² were founded; finance curriculum expanded to include derivatives, risk management, new products, and hedging techniques. There was such a need for trained quants that dozens of graduate programs were launched at major universities to produce financial engineers. Over the three decades leading up to 1998, firms like J.P. Morgan, Swiss Bank Corporation (SBC) (later to become part of UBS, AG), Deutsche Bank, Equitable Companies, Fidelity Funds, Citibank, Goldman Sachs, and some new boutiques emerged in powerful positions.

But others were not as lucky or as quick to acknowledge the sea change in their businesses and markets or to manage the changing risk profiles of the capital markets and their firms. Spectacular downfalls ensued for Kidder Peabody, Barings Bank, Granite Funds, Daiwa's U.S. Bank, Toyo Shinkin Bank, Nissan Mutual Life Insurance, Confederation Life, the Maxwell Companies' pension funds, Drexel Burnham Lambert, Continental Illinois, and Bank of Credit and Commerce International (BCCI), plus many regional savings and loans and credit unions in Japan, Great Britain, Switzerland, and the United States. A lucky few were forgiven by the capital markets long before their woes were over (notably Orange County, California). A few survived with the assistance of governments or via takeovers by stronger partners, but many did not.

During this period, it was no longer possible to distinguish financial institutions merely by their names. For example, insurance companies and mutual funds both made loans and offered check writing (traditional banking functions), while banks began to write insurance and offer families of mutual funds (traditional insurance and investment management functions). The overlap and expansion of businesses changed how top firms were measured. For example, 10 to 20 years earlier the top banks had been measured by total assets, total loans, and total capital.

In the new era, rankings were expanded to include a host of additional measures such as “best foreign exchange house,” “best risk management adviser,” “best equity dealer,” “best commodity house,” and so forth. Another contributor to the transformation of finance was the emergence of off-balance-sheet businesses for many financial institutions. According to the Bank for International Settlements, by March 1995 the notional amount of derivatives outstanding exceeded \$40 trillion and translated into over \$3 trillion in market exposure. By the mid-1990s, some financial institutions had more off-balance-sheet business than on-balance-sheet business. A good example was Bankers Trust, which, as the eighth-largest U.S. bank in 1994, had about \$70 billion in total assets and over \$1 trillion notional amount in off-balance-sheet items. Less than 20 years earlier, the reverse had existed: Off-balance-sheet businesses were at that time dominated by on-balance-sheet businesses for all financial firms.

During this period, central banks 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 assets, BCCI, Barings, Olympia & York, and Lloyd’s due to the lack of a uniform commercial code across nations. Trading blocks in North America, Europe, and Asia emerged, driven by the need for regions with similar economic interests to cooperate and address such issues. A notable turning point in the history of financial engineering came with three financial calamities: the Asian financial crisis of 1997–1998, followed by the Russian financial crisis, followed by the downfall of Long-Term Capital Management (LTCM) in 1998. All of these events raised fears of a global economic meltdown. Also notable at the end of 1998 was the creation of the financial behemoth, Citigroup, that challenged the separation of banking and insurance under the then-in-effect Glass-Steagall Act.

THE MASSIVE GROWTH PERIOD (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. Widespread civil unrest and rioting forced President Suharto to resign after being at the helm in Indonesia for 30 years. A slump in world commodity prices triggered a Russian financial crisis. At the time, oil and gas, timber, and metals accounted for 80 percent of Russia’s exports. A collapse of Russia’s currency, bond, and equity markets followed. On the heels of the Russian financial crisis, Long-Term Capital Management lost almost \$5 billion in less than four months. Fearing potential interlinkages, the Federal Reserve supervised a forced bailout of the hedge fund by major banks and broker-dealers.

These crises led to a new focus on enterprise risk management and the creation of the so-called “enterprise risk manager.” As summarized in Exhibit 1.3, there also was rapid innovation in credit-linked derivatives, plus financially-engineered instruments. During this period, interest rate swaps and currency swaps grew sixfold to almost \$350 trillion,³ and credit default swaps grew from about \$350 billion in 2001 to over \$45 trillion. The economic environment during this period was one of remarkable stability and included flush liquidity, relatively low volatility, low

Exhibit 1.3 Massive Growth (1997–2006)

Date	New Products/ Risk Innovations	Technology	Deregulation/ Regulatory Change	Key Milestones for Different Types of Financial Firms
1996–2000	Synthetic CLOs (1997)	The BlackBerry goes mainstream when Research In Motion (RIM) introduces the BlackBerry Email Solution (1999).	Objectives and Principles of Securities Regulation (IOSCO Principles) (1998).	Collapse of Long-Term Capital Management (1998).
Volatility swaps (1998)	CNBC's release of Worldwide Exchange, the first live news broadcast that is globally integrated, combining the financial markets of the United States, Europe, and Asia (2005).	Repeal of Glass-Steagall Act, thus allowing the merging of commercial and investment banks (1999).		
Correlation options (1999)	Apple launches the iPhone (2007).	First Asian CDO deals were balance sheet transactions issued by Japanese banks.		
Integration of credit and market risk (1998).	Amazon releases the Kindle, setting competitors into finding ways to enter the newly emerging market of e-book readers (2007).	Guidelines set by Insurance and Superannuation Commission allows use of derivative instruments, but very strict guidelines (1997).		
2001–2007	Principal Protected Note (PPN)		Commodity Futures Modernization Act (2000)	National Credit Union Administration (NCUA) allowed Western Corporate Federal Credit Union (WesCorp) to organize a program providing federal credit unions with easy access to financial derivatives market (2000.)

Repackaged assets	Sarbanes-Oxley Act (2002)	DBS Bank securitized \$1.5 billion of CDS on corporate loans in the first Asian synthetic balance sheet CDO deal (2001).
Merrill Lynch introduces first rated collateralized foreign exchange obligation (CFXO) (2007).	Basel II Accord (2004)	By 2004, over-the-counter (OTC) derivatives market reaches \$248 trillion worldwide (market value about \$9 trillion). 40% of volume is traded in U.S., 40% in Europe (mostly London and Frankfurt), and 20% in Asian (mostly Tokyo).
Binary options (2007)	Requirement for hedge fund investors to register under the Investment Advisor's Act of 1940 (2004).	Total volume of non-life insurance-linked securities (ILS) was estimated to be more than \$8 billion, while hedge funds contributed another \$10 billion to other ILS investments in industry-loss warranties (ILW), sidecars, and cat bonds (2006).
Macroprudential indicators/analysis (2000) Enterprise-wide risk management (2000) Expected Shortfall (ES) Financial Soundness Indicators (FSI) Methodology (established by IMF) (2004).		

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 (e.g., Enron and Parmalat) and the bursting of the tech bubble. During this period, the landscape of financial firms changed substantially:

- Citigroup's Sanford Weill became known as the "shatterer of Glass-Steagall" in the United States.
- 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.
- Asset managers such as Fidelity, which had taken over five decades to grow to a few hundred billion in assets under management (AUM), more than tripled their assets during the period to AUMs measured in the trillions.
- Freddie Mac, Fannie Mae, Bank of America, Washington Mutual, Ameriquest, and others became the leaders in sectors of the U.S. subprime mortgage market.
- Quantitative trading grew substantially, due to the success of Renaissance Technologies LLC and many commodity-trading advisors (CTAs).
- G-7 investors massively increased their global presence, focusing particularly heavily on Brazil, Russia, India, and China (BRIC) and other emerging markets.
- Multibillion-dollar so-called club deals (multiple private equity firms pooling their assets to take over huge firms) became common.
- Whereas 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.

During this period, enterprise risk reporting added many new dimensions, especially to capture correlation risk (the risk that multiple asset classes or exposures will deteriorate in concert). Further, value at risk (VaR—a widely used measure of the risk of loss), 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 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.

THE RATIONALIZATION PERIOD (2007 TO DATE, ONGOING)

Expansionary monetary and fiscal policies, combined with substantial deregulation of capital markets and financial firms, had facilitated explosive growth in financial engineering. 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 (for example, Ireland, England, and Spain), the beginning of the current financial crisis commonly is linked to the United States' subprime mortgage defaults that began in earnest in 2007. 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 (for financial and nonfinancial firms alike). The question of whether government regulation had become too lax and whether supervisors did adequate jobs (including regulators, senior managers, boards of directors, and other overseers) is at the heart of current discussion. And the question of whether protectionism and/or regionalism will overtake ongoing globalization appears with increasing frequency in the debate.

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 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. While some instruments are well into their write-down cycle (for example, residential mortgage-backed securities), other instruments are just beginning a likely write-down cycle (for example, commercial mortgage-backed securities and prime residential mortgage-backed securities). Given the breathtaking injections of funds, we pose the question: Will governments and stakeholders (i.e., taxpayers) demand higher levels of regulation and oversight in exchange for those bailout monies? There certainly seems a palpable probability that a reduction in the freedom of global banks is possible as countries and/or regions focus on limiting damage from future crises. Another key factor to consider will be how governments, consumers, and firms respond, determining whether the BRICs/Middle East/sovereign wealth funds emerge with more than 50 percent of the global gross domestic product (GDP) pie after global growth recovers. This will be the first era during which these countries/regions may dominate the global capital markets.

Financial engineering has been forced to enter a rationalization phase. Most firms are in the process of reviewing, rethinking, and/or retooling the procedures, policies, assumptions, and techniques underneath both their specific and enterprise risk management. Regulators, supervisors, and legislators are in the process of conducting substantial reviews and hearings regarding systemic risk and existing

regulatory frameworks. They are conducting investigations into firms that failed or were nationalized. There is little doubt that as Exhibit 1.4 is updated, there will be substantial additions to the “Regulatory Change” and “Risk Innovation” columns.

Some of the questions that will shape this new phase in the evolution of financial engineering are:

- Will increased regulation stifle financial engineering innovation and the over-the-counter derivatives markets?
- How will transparency be increased?
- How will the accountability of overseers (regulators, boards of directors, senior management, and others) be increased?
- What (permanent) changes will be made to compensation models at firms (both financial and nonfinancial)?
- How can data and information sharing, plus cooperation, be improved across central banks, regulators, and policy makers?
- Will the financial utility functions (for example, monetary flows) be separated from financial risk-taking functions (for example, riskier proprietary trading)?
- How will additional regulation or other changes impact the cost structure of financial firms?
- Will stakeholders during this era focus more on revenue and earnings growth (as in prior eras) or more on stable and well-funded balance sheets?
- How will the mix of short-term and long-term funding change, and what will be the impact on the activities of firms?
- How will consumers change savings patterns, and if savings rise substantially, how severely will this rise impact growth?
- Will ratings agency debt ratings be viewed as accurate measures of credit risk?
- How will the aging populations in the established economies impact the next generation of financially engineered products, especially those linked to insurance and pension products?
- What are the new risk measurement models that will be added to value at risk, stress testing, and simulation to improve risk management?
- How can multiple models be used to conduct more thorough analysis of worst cases or expected losses?
- How did common regulatory, accounting, and risk management approaches contribute to pro-cyclicality and the systemic issues?
- Are there new measures of liquidity risk that reveal exposures better?
- How should stress tests be revised, given their weaknesses as set tests that look at past moves and/or have fixed parameters designed for specific positions or strategies?
- How will “too large to fail” or “too linked to fail” change the global landscape of firms?
- What will replace agency ratings as a tool for assessing risk?
- How will firms better align compensation and excessive risk taking?
- Which firms will successfully focus on new business models and business strategies and adapt to the substantial changes in the next phase of the

Exhibit 1.4 Rationalization Period (2007–Present)

Date	New Products/ Risk Innovations	Technology	Deregulation/ Regulatory Change	Key Milestones for Different Types of Financial Firms
2007				Rating agencies have been questioned regarding the accuracy of their ratings of certain financial instruments, especially residential mortgage-backed securities (2007).
2008–2009	IBRD and IDA offer high-risk countries weather derivatives to help with loss of food supply.	The Cray XT5 supercomputer, also known as the “Jaguar,” is bestowed the title of world’s fastest computer, with the ability to process 1.75 petaflops (quadrillions of floating point operations per second) (2009).	Financial Services Authority (FSA) introduces remuneration code of practice, which requires banks, building societies, and broker dealers in the U.K. to implement policies that promote effective risk management (2009).	Insurance giant AIG became government-controlled after the Federal Reserve saved the firm through an \$85 billion bailout; government feared the possible collapse of AIG because it had provided numerous insurance contracts to investors who bought complex securitized products. Two of the largest investment banks, Morgan Stanley and Goldman Sachs, create commercial bank branches (2008). Barclays Capital purchases Lehman Brothers’ broker-dealer unit, which potentially pushes the U.K. bank into top 10 positions across many parts of investment banking, such as global M&A, and global equity and debt capital markets (2008).
	Pay-option adjustable-rate mortgages for the worst residential mortgage credits.			

(Continued)

Exhibit 1.4 (Continued)

Date	New Products/ Risk Innovations	Technology	Deregulation/ Regulatory Change	Key Milestones for Different Types of Financial Firms
2010			<p>U.S. announces intention to collect "TARP" tax from financial firms (2010). Hearings continue regarding systemic risk and the role played by various financial firms around the world (2010).</p> <p>European Commission continues to review restructuring plans submitted by nationalized banks of member countries (2009, 2010).</p> <p>Obama, following a suggestion by Volcker, announces he will pursue the separation of the utility functions of banks from the risk-taking function of banks.</p> <p>Britain announces windfall tax on bonuses given by financial firms (2010).</p>	<p>PIMCO Total Return Fund, the world's largest bond fund, contains nearly \$193 billion in total assets, much of which has been accumulated through derivative exposures—the fund buys futures contracts or other derivatives in order to obtain exposure to bonds.</p>
				<p>NCUA took over U.S. Central Federal Credit Union (with \$34 billion assets) and WesCorp (with \$23 billion assets). After a stress-test of the asset-backed securities held by the two credit unions NCUA concluded that the risk of the securities were too high.</p> <p>Hundreds of additional smaller bank failures are expected in the United States and around the world (2010).</p>

capital markets and financial engineering, and which will lose their way by focusing too narrowly on their response to the financial crisis?

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NOTES

1. Source: International Swaps and Derivatives Association, Inc. (www.ISDA.org)
2. www.iafe.org.
3. Source: International Swaps and Derivatives Association, Inc. (www.ISDA.org)

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