The History of Financial Derivatives: A 2-Part Feature

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The views expressed in this article are the personal opinions of Hilary Till and do not necessarily reflect the views of organizations with which Ms. Till is affiliated.

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Part 1: The Emergence and Development of Financial Derivatives Post-Bretton Woods

Abstract
This 2-part series discusses the emergence of financial derivatives after the collapse of the Bretton Woods accord in 1971. In Part 1, the article explains the concepts that enabled financial derivatives markets to flourish, focusing on the required mathematical concepts. Part 2 continues with enumerating the business models that have been employed by successful commercial participants in the financial derivatives arena. Part 2 also briefly covers the development of over-the-counter financial derivatives, including their misuse during the lead-up to the Global Financial Crisis. The article concludes with the possibility that we may be nearing the limits of what the power of mathematics can do to hedge, and thereby conquer, financial risk.

The Emergence of Financial Derivatives Post-Bretton Woods

Post-World War II, Essentially the Gold Standard: No Need for Hedging
Examining the history of currency arrangements, in “the summer of 1944, delegates from 44 countries met in the midst of World War II [at Bretton Woods, New Hampshire to reshape] the world’s international financial system,” recounted Schifferes (2008). At this conference, John Maynard Keynes unsuccessfully floated the idea of an alternative post-war currency, the “Bancor,” which was to be anchored by 30 commodities, a broader base than the Gold Standard. Instead, noted Conte and Karr (2001), “the leaders decided to tie world currencies to the dollar, which, in turn, they agreed should be convertible into gold at $35 per ounce.” This created a modified gold standard. Therefore, when the Bretton Woods system functioned, there was no pressing economic need for derivatives to hedge currency risk.

No Anchor, Post-Bretton Woods
“In 1971, the US … unilaterally went off the gold standard and devalued the dollar … This led to the abandonment of fixed exchange rates and the introduction of floating rates, where the value of all the main currencies was determined by market trading,” explained Schifferes (2008).

With the U.S. dollar no longer pegged to gold or anything of fixed value, the risk of large price changes entered the markets. As reviewed by Leo Melamed, Chairman Emeritus of the Chicago Mercantile Exchange in Melamed (1994), “the collapse of the Bretton Woods Agreement … ushered in an era of considerable risk in currency price fluctuation – risks which could be limited if there were a viable market for currency futures trading.” As a result, the Chicago futures exchanges developed innovative financial hedging instruments in both currencies and interest rates in the 1970s and 1980s.

Arguably, outside of the United States, there was a different response to floating exchange rates. According to Hammes and Wills (2005), from the end of WWII through late 1971, “10 [to] 15 barrels of oil would buy an ounce of gold. … [This] situation changed [temporarily] … in the early 1970s.” That said, this long-term relationship appears to have regained its validity, even though the dollar price of oil has had wide fluctuations since the 1970s. Please see Figure 1.

Hammes and Wills (2005) hypothesize that after the end of the Bretton Woods accord in 1971, there may have been an implicit pegging of oil to the price of gold by oil producers in order to anchor the real value of their sales.
Perhaps oil producers implicitly resumed this peg in the mid-1970s, arguably by adjusting oil production according to what produced a reasonably constant gold price of oil. This would add a fundamental rationale to the observed empirical relationship. Figure 2 shows how the value of oil in gold was destabilised in the mid-1970s, but then stabilised by the end of the 1970s.

Figure 1: Historical Relationship between Gold and Oil

The Essential Concepts that Enabled Financial Derivatives Markets to Flourish

For the U.S., though, the solution to dealing with floating rates has been the use of financial derivatives. There have been two essential concepts that have enabled financial derivatives markets to flourish. The first is the use of maths to attempt to conquer financial risk. For all financial exposures, one looks for underlying risk factors, which can then be aggregated at the portfolio level. These portfolio-level risk factors can then be hedged through derivatives. The second concept is the development of appropriate business models. Financial derivatives have enabled market participants to choose what type of risk-bearing they will specialise in, and which types of risk they can lay off to other risk-bearing specialists.

The Use of Maths to Conquer Financial Risk

The following seven mathematical concepts have been useful in managing financial risk: (1) bond math; (2) Modern Portfolio Theory; (3) the application of the no arbitrage principle; (4) the
Taylor expansion; (5) parsimonious modelling techniques; (6) Value-at-Risk; and (7) event-risk measurement. We will briefly describe each concept below.

1. Bond Maths
We can dissect bond risk at the security and portfolio level through measuring the relevant instrument’s exposure to interest-rate risk. Then with this dissection of interest-rate exposure in a bond portfolio, one can decide if any of the various exposures are desirable, and whether any of these exposures should be hedged with interest-rate derivatives.

2. Modern Portfolio Theory: Thinking in Terms of Risk Units
One concept essential for the development of financial hedging instruments is to be able to think of portfolios in terms of risk units. This was achieved in the 1950s with Harry Markowitz’s Modern Portfolio Theory, which was explained in Elton and Gruber (1997). Markowitz “formulated the portfolio problem as a choice of the mean and variance of a portfolio of assets.” An “investor … [should] choose his or her preferred portfolio, depending on individual risk-return preferences.” “The important message of the theory was that assets could not be selected only on characteristics that were unique to the security.” “Rather, an investor has to consider how each security co-moves with all other securities.” By “taking these co-movements into account,” one could “construct a portfolio that has the same expected return and less risk than a portfolio constructed by ignoring the interactions between securities.”

The later development of Value-at-Risk for monitoring a portfolio of diverse derivatives instruments was a natural extension to the way of thinking that had begun with Modern Portfolio Theory.

3. No Arbitrage Principle for Derivatives Pricing
The no arbitrage pricing approach, which is summarised in Box 1, was a seminal conceptual development for the valuation of derivatives.

**Box 1**

“The no arbitrage pricing or contingent claims pricing approach for valuing a derivative proceeds as follows:
1. Start with a description (model) of the future payoff or price of the underlying assets across different possible states of the world.
2. Construct a portfolio of underlying assets that has the same … payoff as the derivative.
3. Set the price of the derivative equal to the value of the replicating portfolio.”

*Source: Carpenter (2011), Slide 3.*

We can apply this approach to both forwards and options. For forwards, the price should equal the cost of buying the security and carrying it over to maturity, which, in turn, is equal to the spot price plus the cost-of-carry minus the benefits-of-carry. While for options, a dynamic description of valuation is required. Essentially one can dynamically replicate the changing value of the option on an asset by buying and selling the underlying asset in proportions determined by the option’s changing delta. The sum of the profits and losses from this buying-and-selling activity becomes the option’s value, once one takes the present value of each of these gains and losses. The option’s value cannot deviate from this summation; otherwise, there would be an arbitrage opportunity. Black and Scholes came up with a closed-form mathematical equation for this dynamic replication, assuming one can continuously carry out this replication over infinitesimally small time intervals.
4. Taylor Expansion

Box 2
This series “is called the Taylor series of the function f at ...”

\[ f(x) = \sum_{n=0}^{\infty} \frac{f^{(n)}(a)}{n!}(x-a)^n \]

\[ = f(a) + f'(a)(x-a) + \frac{f''(a)}{2!}(x-a)^2 + \frac{f'''(a)}{3!}(x-a)^3 + \ldots \]


5. Parsimonious Modelling Techniques

Another key concept is to come up with models for a complex portfolio of securities and derivatives using only a handful of factors. In other words, one wants parsimonious models. Then if a portfolio can be described by a handful of risk factors, it will be easier to design macro hedges using a handful of derivatives for that portfolio.

Vannerem and Iyem (2010) explain that “yield curve dynamics can be described by [three parameters: the shift, twist, and butterfly] STB movements. These three movements are the driving factors of interest-rates changes across the term structure. They capture between 90 and 98% of interest rate variation in most developed markets ..."

This type of modelling is an excellent response to Milton Friedman’s 1977 call for an examination of “how the whole term structure of yields ... [could] be described more compactly by a few parameters,” as cited in Nelson and Siegel (1987).

“The Shift/Twist/Butterfly movements are, in order of importance, as follows:
(1) Shift, which captures the changes in the level of the yield curve;
(2) Twist, which captures the change in the slope of the yield curve; and
(3) Butterfly, which captures the changes in the curvature of the yield curve,”
as summarised in Vannerem and Iyer (2010).

Another useful concept is the Taylor expansion; please see Box 2. This formula underlies bond duration and convexity as well as all the various Greeks used in option risk measures.

Analogous work has been done in asset allocation with factor models. Factor “models are generally classified in three groups: fundamental, statistical, and econometric,” wrote Wolfe (2008).

In Figure 3, Callan Research (2012) provides an illustration of “factors, grouped by type of exposure across different categories. ... For example, macroeconomic factors are applicable to most asset classes while equity and fixed income factors deconstruct characteristics within those two broad asset classes.”

“Other types of factors include liquidity, leverage and private markets, for which marketable proxies are challenging to find. It is possible to reconstitute an asset class from these building blocks. Cash would be the combination of real interest rates and inflation. And core bonds would add some of the elements that are under the ‘fixed income’ heading. Investors can gain exposure to factors via investable proxies, although some factors are easier to access than others,” as explained in Callan Research (2012). For our purposes, we note that derivatives enable one to use a factor-modelling approach in portfolio construction.
6. Value-at-Risk
Another crucial mathematical concept for derivatives development is the Value-at-Risk (VaR) metric. VaR summarises the expected worst loss over a target horizon within a confidence interval. While VaR is useful, it has to be used jointly with other measures.

7. Event Risk
Using long-term data, one can directly examine the worst performance of a derivatives position under similar circumstances in the past. In practice, such a measure can sometimes be larger than a Value-at-Risk measure based on recent volatility.

To illustrate this concept, one example portfolio consisted of a long Russell 2000 vs. a short S&P 500 futures trade and a long Municipal Bond vs. a short U.S. Bond futures trade. These trades were normally unrelated. But during a scenario test of the portfolio's sensitivity to event risk, which is shown in Figure 4, one finds that the combination of the two trades resulted in an exposure to a liquidity shock. The short legs of each spread were the more liquid of the pair. Both of these trades were at risk to a flight-to-quality event as happened during the Fall of 1998.

One can use event-risk measurements to decide on the appropriate leverage level for a portfolio.
In Part 2, we will finish discussing the essential concepts that enabled financial derivatives markets to flourish by covering what the appropriate business models are for commercial participants to successfully use financial derivatives. Part 2 will conclude with a discussion of how market participants seem to be once again searching out stable valuation benchmarks as an anchor of value rather than exclusively relying on financial derivatives for conquering volatile financial risks.

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Part 2: The Possibility That We Are Coming Full Circle

Abstract
This 2-part series describes the emergence of financial derivatives after the collapse of the Bretton Woods accord in 1971. Part 1 explained the concepts that enabled financial derivatives markets to flourish, focusing on the required mathematical concepts. Part 2 continues with enumerating the business models that have been employed by successful commercial participants in the financial derivatives arena. Part 2 also briefly covers the development of over-the-counter financial derivatives, including their misuse during the lead-up to the Global Financial Crisis. The article concludes that we may be nearing the limits of what the power of mathematics can do to hedge, and thereby conquer, financial risk.

The Essential Concepts that Enabled Financial Derivatives Markets to Flourish

The Business Models
A key conceptual development in enabling financial derivatives to flourish has been the creation of appropriate business models for those involved in financial derivatives.

1. Successful Asset Managers Must Be Experts in Portfolio Theory
Successful asset managers must choose which risks they have an edge in; they need to decide how to size and combine the chosen risks; and finally they have to decide which particular risks to hedge, at either the factor or macro level.

2. All Viable Financial Intermediaries Manage Basis Risk
Essentially, in order for derivatives markets to work, there needs to be a demand by investors or commercials to lay off a first-order risk (such as interest-rate or foreign-exchange risk.) These participants will not mind doing so as long as the cost is small compared to the overall profits of their investment or business enterprise. With these volatile risks hedged, a commercial entity can then focus on their chosen area of expertise and engage in long-term planning, despite uncertainties in the financial markets.

Typically, a price-risk specialist (or speculator) will take on this first-order risk and hedge this exposure with a related derivative or security, creating a smaller exposure or basis risk, which they are experts in managing. The price-risk specialist will often be a part of a specialised firm, which is set up to efficiently and cost-effectively manage a basis risk. A basis relationship tends to be more stable and predictable than various outright risks (like the direction of a currency pair or long-term interest rates.) As long as various basis relationships are sufficiently stable and predictable, entire institutions can be created around an expertise in the assumption and management of various basis risks. Goldman Sachs is one such institution. Chicago proprietary trading firms are another example.

In a post-Bretton Woods financial world of floating currencies and interest rates, businesses have (arguably) been able to flourish, despite all the uncertainties in financial variables, because they have been able to hedge those risks in a cost-effective way through basis-risk specialists.

Interestingly, a basis-risk specialist may choose to lay off some further specialised risk to another price-risk specialist, who in turn may do the same, which then creates an entire “food-chain” of interconnected, highly-specialised financial intermediaries. What derivatives markets have made possible is the specialisation of risk-taking rather than the elimination of risk.
A key aspect of basis-risk handling is that the activity in itself cannot be very profitable; otherwise, no commercial would pay for the service of having risks hedged. So the profitable management of basis risk relies on the ability to handle these risks in a leveraged fashion. Therefore, there is constant pressure to find ways to minimise the capital used to undertake this business. If the business becomes too capital intensive, the activity will not be viable.

Another key aspect of basis-risk handling is that even when a price relationship is highly statistically significant, there will always be anomalous events. The Long Term Capital Management implosion in 1998 is a good example. What leverage level and how one carries out the risk management of this activity generally determines whether such a business has a long-term future (or not). In LTCM’s case, it turned out to be inadvisable to assume that a theoretical boundary condition would hold: that a sovereign would not default on debt issued in its own currency. Russia did precisely this in 1998. Analogously, in AIG’s case, it turned out to be inadvisable to assume that U.S. housing prices could not plummet. This happened, starting in 2007.

The Emergence of Over-the-Counter (OTC) Derivatives

Rationale
As explained in Moore and Khoja (2008), OTC derivatives emerged since they provided companies, who were hedging risks, the ability to enter into “customized contracts ... [that matched] their unique risk profiles.” Historically, companies could “hedge without posting daily margins ... [on] exchange[s].” Arguably, the latter rationale is the main reason for the explosion in OTC derivatives over the years.

Regulatory Forbearance
Perhaps surprisingly, over-the-counter derivatives markets flourished from 1981 onward, even though there was regulatory and legal uncertainty in these markets until 2000. “Congress embraced wholesale legalization of OTC derivatives in 2000 with the Commodities Futures Modernization Act,” wrote Stout (2009).

Credit Risk and Appropriate Measures
With the possibility of swaps not being margined over long timeframes, new metrics were developed for the accumulating credit risk associated with having an in-the-money swap.

Disciplined Internal Processes for Institutional Investors
After a number of high-profile institutional blow-ups due to the inappropriate use of over-the-counter derivatives in 1994, institutional investors had to come up with new disciplined internal processes.

Figure 1 demonstrates one such disciplined internal process.
The Global Financial Crisis and its Aftermath

1. Questionable Incentives and Leverage

The global financial crisis and its aftermath is causing large changes in the derivatives marketplace. "Credit-default swaps (CDS) are insurance-like derivatives, or side bets, that protect investors from bad events like a company going bankrupt or a country failing to pay its debts," wrote Eisinger (2012). They are equivalent to puts. In viewing the events of 2008, there have been legitimate questions about the ability to enter into CDS on corporate names, when an investor has no economic exposure to that name. Some have even compared such activity to buying fire insurance on a neighbor’s home.

Prior to 2008, recounted Ritholtz (2012), “[t]he biggest underwriter of [over-the-counter credit] default swaps was AIG, the world’s largest insurer. Without [a] ... reserve-requirement limitation, it was free to underwrite as many swaps as it could print. And that was just what it did: AIG’s Financial Products unit underwrote more than $3 trillion worth of derivatives, with precisely zero dollars reserved for paying any potential claim." Later, the firm became the recipient of a “$185 billion ... government bailout.”

2. Re-engineering the OTC Marketplace

The global swaps market is dramatically changing, due to the Dodd-Frank Act. As summarised by Moeller and Walsky (2012): “The act mandates increased transparency and requires firms to execute potentially 90 per cent of swaps electronically, either on a designated contract market or a Swap Execution Facility ..., a new type of trading venue. Trades will then clear through a central counterparty ...” This requirement shifts systemic risk to clearinghouses. Ultimately, the trend is for swaps to essentially be “transformed into futures contracts as Dodd-Frank Act regulations ... impose higher margins and capital for swap users compared with futures,” wrote Leising (2012).
Possibility That We Are Coming Full Circle

In the commodity markets, there has been a debate on the so-called financialisation of the commodity markets, leading to ever more leveraged commodity markets. One could argue that a larger current trend is the backing of derivatives by not only additional collateral, but also real assets, leading to an ever more deleveraged financial marketplace.

“In October 2009, the CME Group said it would allow physical gold to be used as collateral for margin requirements [in London], a move that was followed by its rival, the IntercontinentalExchange, in late 2010” at ICE Clear Europe, reported Freeman (2011), who also noted that “in February … [2011], JP Morgan Chase & Co. announced its decision to accept physical gold as collateral in some financial transactions.” MacDonald (2012) stated that “LCH.Clearnet Group Ltd. has … been using gold as collateral since 2011.” And in August 2012, CME Clearing Europe “announced it had extended the range of eligible collateral types to include gold bullion,” according to the CME Group (2012).

By allowing gold as collateral, investors, at least in Europe, can hold assets in gold, but still get exposure to the potential upside of financial markets through derivatives. In a way, one could argue that they are starting to implicitly recreate a private form of the Bretton Woods accord: they have financial instruments that are at least partly backed by gold.

In addition, separately, in 2011, the launch of several exchange-traded funds, backed by a variety of physical metals, in addition to gold, did provide commodity investors with new investment options. It appeared at the time that retail investors were also starting to intuitively recreate the Bretton Woods accord: by holding metals-backed financial instruments.

The Governor of the People’s Bank of China wrote in Xiaochuan (2009) that he regretted that Keynes’ Bancor proposal had not been accepted. With the Bancor, all currencies would have been pegged to a basket of commodities, providing a stable benchmark. The Bank of China governor stated that “[t]he acceptance of credit-based national currencies as major international reserve currencies, as is the case in the current system, is a rare special case in history.” But he noted that “[t]he re-establishment of a new and widely accepted reserve currency with a stable valuation benchmark may take a long time.”

Therefore, for now, we can expect that there will be a consensus that financial derivatives will continue to be valid tools in managing volatile financial risk.

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