Demystifying Exotic Products

Interest Rates, Equities and Foreign Exchange

Chia Chiang Tan
To my father and
in memory of my mother.
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Foreword

It must be difficult being an investment professional in these times: miniscule bond yields and a moribund economy too weak to sustain stock market outperformance. Do you resign yourself to paltry bond coupons and put aside more cash in anticipation of future needs, or do you just unleash all you have got into the stock markets and pray for the best?

There must be another way. What if you can have better control over risks and yet participate in a rising market? This brings us into the realm of derivatives. But are they not inherently risky and dangerous instruments to deal with? In a sense the answer is yes! In the same way, a sharp kitchen knife or the driving of a car may cause fatalities if one fails to understand and control the dangers involved. However once the risks are mastered, they become indispensable “tools” of our society.

In a sense the situation is similar when derivatives and structured products are used to shape the individual portfolio allocation of an entity’s assets and liabilities. Contrary to popular misconception, structured products are inherently risky only if applied without care. For example, assume a French aerospace company wins a contract to export aeroplanes to the US with payments taking place in 18 months from now upon the delivery of the products. The company faces a dilemma: the production costs occur in Euros whereas the revenues will be paid in US dollars. The company could potentially go out of business if the US dollar should collapse relative to the Euro in 18 months from now. Whether one likes it or not: The business transaction makes the company intrinsically long a currency future leaving it exposed to large risks. If derivatives are used wisely in this case, the company’s risks can be minimized or even eliminated.

If this view is correct, how can one best understand the risks as well as the opportunities that derivatives can potentially offer? Why should one trust investment banks that have foremost their own sales targets in mind but not necessarily the best solution for the client’s investment goals?

Bookshelves are flowing with countless technical books on derivatives describing Brownian motions and (re-) derivation of the Black–Scholes formula. However what one needs is a book that describes the potential and risks of the major derivatives products that have been around.

Chia takes a refreshingly unique approach by concentrating on how exotic products have arisen in the last decade to address investors’ risk-reward preferences. He explains the economic rationales behind various esoteric products, their key features, as well as situations in which clients have inadvertently found themselves more exposed than they thought.
From my time in industry, I have seen too many occasions when users of derivatives failed to grasp the big picture risks and paid heavily for it. It is much more important for investors to understand if derivatives are suitable as per their investment circumstances, than if they got good prices for the derivatives. Like an insurance contract, you need to ascertain if specific eventualities are provided for, or whether you should consider taking out additional cover.

This book makes compelling reading for anyone interested in structured products. And if you happen to be studying the mathematics behind financial derivatives, why not have a look at why there is demand for them in the first place? It might give you a better perspective as to the products at the end of the assembly line.

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Munich
Preface

As a consequence of the credit crisis of 2008, there is probably no other period in recent financial history where derivatives have received the same amount of negative publicity as today. However, the media coverage rarely provides more than a superficial explanation of derivatives. So, despite all the hype, does the public really know what derivatives are?

I make no excuses for the excesses of the credit markets and some of the esoteric instruments they trade (e.g. CDOs squared), which have wreaked extensive havoc on the financial and real economy. But derivatives are as different from each other as the animals that roam the land, and whereas the lion is to be feared, the hare is mostly harmless, while the horse can help its rider to cover great distances. In the same way, there are derivatives out there that can be quite useful in engineering an investment strategy suited to an investor’s risk–reward preferences.

Whether derivatives are dangerous or not depends on the terms of the contract. A lot of negative sentiment towards derivatives comes from people who do not understand them. After all, would you feel comfortable in harnessing the power of electricity if you do not know how to avoid fire hazards from its unsafe use? It would be very helpful if we could demystify derivatives. The tendency of the existing literature to focus on an exclusive audience with stochastic calculus training has left a very wide gap. However, term sheets for most exotic products tend to involve only simple mathematics (addition, subtraction, multiplication, division, the summation notation and symbolic representation of quantities). So, why is it not possible to explain derivatives in simple terms?

The pricing of exotic products indeed involves complex mathematics. However, investment professionals should not typically need to understand pricing. (They are unlikely to possess the necessary infrastructure to price exotic products anyway.) Pricing is important to a financial institution selling these products, since it then tries to offset the risks by trading in simpler instruments. The investment professional, however, often buys these products with the aim of executing an investment strategy consistent with a market view. It is thus more important to understand whether the characteristics of this product make it suitable for her. For example, if a product pays you $100 if, on 15 December 2008, Microsoft stock trades above $30 and $0 otherwise, you would have been paid nothing since the market tanked late last year. Isn’t it more important to understand that you are betting everything on the price of Microsoft stock on one particular day in the future, than whether you should have paid $40 or $45 for this product? Does neglecting pricing sound like taking too much on trust? If so, ask yourself whether you can confidently determine if the price of a stock you have just bought should really be $27.
Of course, a minority of operators have put derivatives to bad use, e.g. to take on more leverage than otherwise possible, or to window dress the profit if accounting regulations allow for different treatment of derivatives to the underlying. But should that be a reason to condemn derivatives, or rather a reason to close loopholes that allow less than scrupulous market participants to game the system? After all, a knife could be used to kill. But top chefs need it to prepare gourmet dishes too.

There are plenty of good books in finance, but they often provide a general description of assets, or give a long list of (usually first-generation exotic) products and how to price them (mainly using some simple model like Black–Scholes), or introduce the mathematics behind some sophisticated model. But very little exists that explains exotic products – what they are, why they are of interest and how to think about them intuitively – at least in terms that someone in the wider financial industry can understand.

This book is intended to provide an intuitive explanation of exotic products. We shall explore the major themes in the construction of structured products, with the discussion in the remainder of the book centred around these themes. After all, the products can fall out of favour as economic circumstances change, but the themes have far greater longevity. For instance, one such theme is to provide for full repayment of the investor’s principal at maturity regardless of market conditions. Whether we are in an environment of high or low interest rates, a recession or a boom, this sort of controlled risk investment strategy will always be in demand.

Rather than provide an exhaustive product coverage, this book shall give a flavour of the types of products that exist. Nor is it going to delve into the mathematics behind the latest models. The reader will instead be shown why such strange products as constant maturity swaps exist, what they really are, who is bearing the risk, and will be given a little framework to think about pricing them.

This book covers mainly interest rates, equities and foreign exchange. I shall make almost no reference to structured products in credit and hence hopefully be spared the accusations of being an apologist for an area that is associated with the worst financial crisis in decades. After all, I am more interested in providing the readers with a framework in which to understand products that are likely to make a strong comeback in the years ahead, than in providing them with a historical insight into a catastrophic episode of financial mis-engineering.

Starting with the economic background that favoured the explosion of exotic products, the book proceeds to outline some major themes in the construction of structured products, then moves on to the basics of derivatives pricing. Next, the “building blocks” of exotic products are examined: barriers, quantoes, constant maturity swaps and range accruals. The book subsequently explains how more yield can be bought by incorporating early termination features in the products, and the remaining chapters focus on some esoteric products that involve pathwise accumulation, baskets where averages or extreme points are of interest, direct bets on volatility or correlation, and fund derivatives.

These products will illustrate some of the innovations of structured derivatives in the last decade. In fact, the reader shall see that, contrary to the misconception that derivatives are inherently dangerous, they can be either quite safe or extremely dangerous, dependent on the risks the investor chooses to take. And perhaps some derivatives were initially designed to satisfy certain investment requirements, but have subsequently been modified in the quest for higher yield so that their inherent protections have now disappeared. Some analysis aided by hindsight should hopefully help investment professionals to avoid these pitfalls in the days ahead.
I do not claim that derivatives are for everyone, but the reader is invited to learn for himself what they really are and decide if they can work for him. It is by understanding what one may be involved in that best serves the financial professional. The book concludes by speculating on which of these products might survive the credit crisis of 2008 and post-crisis deleveraging and risk aversion.

It is hoped that this book could assist investment professionals in seeing how derivatives can be used to construct strategies with certain desired risk–reward profiles. Quants, structurers and traders could benefit from seeing how derivatives are utilised to provide solutions to various client demands; students could benefit from seeing how derivatives theory is applied in practice; and perhaps this book could demystify derivatives for the general public. Further, as this happens to be one of the most tumultuous times in living memory for the financial industry as a whole, many products that thrived in the golden days of derivatives may not survive going forward. This book could serve as interesting reading for future generations about what existed in our times.
I am indebted to various friends and former colleagues for their encouragement and assistance in my endeavour to write this book. Firstly, I should thank Dr Alex Langnau for extremely helpful suggestions from his review of the manuscript, and his unwavering focus on getting me to reach out to the reader. His efforts were crucial to improving the readability of the material. I should also thank Dr Andrey Gal for insightful discussions on the subject matter and for a critical appraisal of the contents of the manuscript.

I am grateful to Andy Tran for providing a review from the perspective of someone in a different asset class (credit) to those I cover in the book. I further owe it to John Spalek for providing a partial review of the material. His attention to detail was instrumental in weeding out some errors in the manuscript. This book is not just written with quants or even investment bankers in mind, and their feedback is essential to ensuring that other finance professionals can understand the material.

I am indebted to Shiv Madan, Lars Schouw and Andy Tran (again) for helping me to source out data for use in the material. Such data is mainly obtained from Bloomberg. Without their assistance, it would have been more difficult for me to complete this book.

Finally, I must thank the staff at Wiley (in particular Pete Baker, Aimee Dibbens and Ilaria Meliconi) for being a real pleasure to work with prior to, and during, the book’s production. Any errors in the material are solely my responsibility.
In the interbank market, the quote style is ccy1/ccy2, which rather confusingly means the number of units of currency 2 per unit of currency 1. For example, the exchange rate between the dollar and the yen is quoted as USD/JPY (i.e. number of yen per dollar). On the other hand, EUR/USD is the number of dollars per euro.

Typically, the order of the currencies is chosen so that the quote is bigger than 1, e.g. USD/JPY is about 90, whereas JPY/USD (not the convention except in some US futures exchanges) would be around 0.011. Also, where possible currency 2 should be a decimal-denominated currency (not really relevant today). In the past, the Australian dollar was not divided into decimal units, so the quote was AUD/USD rather than USD/AUD.

In the CME Group, some FX pairs are quoted as number of dollars per unit of currency (e.g. JPY/USD). It makes these currency futures similar to futures in any other dollar asset.

### NOTE ON THE SUMMATION NOTATION

The summation notation is defined as follows:

$$\sum_{i=1}^{N} A_i = A_1 + A_2 + \cdots + A_N.$$  

### NOTE ON EXPECTATION

The expectation operator with respect to measure $Q$ is denoted $E^Q[\cdot]$. Expectation is best understood as taking an average, based on probabilities of possible outcomes.

There is no need to understand the concept of a measure to follow the material in the book. The basic idea is that the choice of a numeraire asset (i.e. a unit to measure value) defines the associated measure, which then determines a set of probabilities (for purposes of computing the expectation). These are not real-world probabilities, but rather implied from an analysis of the process of hedging.
NOTE ON SUPERSCRIPT

In much of my material, a superscript number represents raising the quantity to a power. So,

\[ A^4 = A \times A \times A \times A. \]

However, at times, I have used the superscript as another index, especially when I need the subscript to indicate time, e.g. \( S^t_i \) represents the price of stock \( i \) as seen at time \( t \). In these cases, I always define the variable \( (S^t_i \) here) concerned.

Hopefully, the meaning of the superscript should be clear from the context.
Derivatives in their Golden Days
(1994 to 2007)

The years between 1994 and 2007 have seen a period of low inflation and low interest rates in most developed economies. With the exception of Japan, these years have also seen staggering rises in the prices of stocks and real estate. The periodic crises (e.g. the Asian crisis which began around July 1997, the bursting of the dotcom bubble in March 2000, or the terrorist attacks on 11 September 2001) have not significantly altered the financial landscape for the worst, at least when compared with the stagnation of the late 1960s, the periodic recessions throughout the 1970s and early 1980s, coupled with sky-high inflation in the late 1970s. The current economic climate since the burst of the sub-prime bubble in August 2007 might herald a less benign era, but that is still something unfolding at the time of writing. Nevertheless, we must approach the explosive growth of derivatives in the light of what could be considered the last two golden decades.

Derivatives are simply products whose payoffs depend on the values of other underlying market variables. For example, an agreement to buy a stock 1 year from now at a pre-agreed price is a derivative since its value depends on the value of the underlying stock.

Since the publication of the Black–Scholes model in 1973, a new framework for understanding derivatives and managing risk has taken shape. Derivatives have existed for a long time (e.g. rice futures in Japan in the 1700s) and have been used to transfer risk. The concept of the traditional insurance, which has also been around for some time, is really also based on risk transfer. However, with an improved framework for pricing and managing risk post-1973, substantial innovations in derivatives occurred as more players entered the field. The advances in technology which allowed for high-powered computing of the prices of derivatives also contributed significantly to their growth on an industrial scale.

Ultimately, however, the economic environment contributed heavily to the demand for derivatives from the investing public. In particular, in a low interest rates environment, can one be blamed for seeking higher yields through other means? And if, as policy-makers would have you believe, the boom–bust cycle has been tamed and we are now in a period of steady growth, is it not appropriate to leverage up with derivatives in our pursuit of yield? Further, corporates with hedging needs have certainly welcomed customised solutions that deal with projected cashflows.

In the following sections, we shall be visiting various products and concepts. Please do not be too bothered if you cannot follow all the products and features mentioned. They are meant more to show the myriad of innovations in derivatives stemming from the environment of the last decade or so. And the concepts will be fully discussed in the remainder of the book. Please note that there is a glossary at the end of the text in case you need to remind yourself of the definition of a new term.
1.1 USES OF DERIVATIVES

Put simply, there are two main purposes of derivatives

(1) hedging
(2) speculation

Hedging

Hedging is where an individual or firm takes a position, with the aim of protecting against an adverse movement in the market environment. As a simple example, suppose you are a US dollar investor and need to pay €100 for some item 1 year from now. It is unclear what spot EUR/USD would be worth 1 year from today. Figure 1.1 shows that as spot EUR/USD (1 year from today) varies between 0.5 and 2, the dollar cost of the €100 payment varies between $50 and $200.

Figure 1.1 As the EUR/USD spot FX rate (1 year from today) varies from 0.5 to 2, the dollar cost of a €100 position varies from $50 to $200.

(Note that the usual style of FX quotation in ccy1/ccy2 is number of units of currency 2 per unit of currency 1. So, EUR/USD refers to number of dollars per euro. The “/” symbol can be misleading for one with mathematical training, as it wrongly suggests itself as the number of euros per dollar.)

You might want to lock in the rate of exchange by entering a 1-year forward, agreeing to buy EUR/USD at 1.3 (i.e. to pay $130 for €100), rather than wait until 1 year from now and be at the mercy of the exchange rate at that time. Figure 1.2 shows that as EUR/USD varies from 0.5 to 2, the forward contract has payoff varying from $80 to $70. Notice that you incur a loss on the forward contract itself if EUR/USD 1 year from now is less than $130. However, the forward contract offsets the dollar cost of buying euros, so that the net cost is always $130 (see Figure 1.3).

Suppose, instead, you are not sure you would need to enter the transaction and just want the right (but not obligation) to buy €100 for $130 at the end of 1 year. This is a call option. Figure 1.2 shows that the call option and the forward have the same payoff if EUR/USD is above 1.3, but otherwise the payoff of the call option is 0. Since you could walk away if EUR/USD is less
Derivatives in their Golden Days (1994 to 2007)

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Figure 1.2  Dollar payoffs of a forward and a call option on EUR/USD based on different realised values of EUR/USD. Both the forward and the call option have increasing payoffs as EUR/USD increases but the payoff of the option does not go below zero when EUR/USD falls below 1.3.

than 1.3, the call option must cost something up front. This cost is referred to as the premium. Figure 1.3 shows that the call option allows you a lower cost of euro purchase if EUR/USD drops below 1.3, while still ensuring that you never pay more than $130.

Perhaps you think the option costs too much. Could you give away some protection for a cheaper option? Perhaps you could have the same option with a knockout barrier so that the option expires worthless if EUR/USD drops below 1.15 any time before the end of the year. In this case, you will be unprotected if EUR/USD drops to 1.14 after 6 months and then rises back above the strike of 1.3 by the end of the year. (See Figure 1.4 for an illustration of this.) But then, nothing in life is free.

Figure 1.3  Resultant dollar payoffs when we superimpose the hedges (either forward or call option) on the short EUR/USD position (from the requirement to purchase €100). For the forward contract, the net effect is that you buy €100 at $130. For the call option, the net effect can lead to a cheaper cost of euro purchase if EUR/USD drops below 1.3.
I hope, nevertheless, that you get the point that derivatives can be used for hedging – and optionality costs money. You can also sell some optionality, thus making the existing product cheaper.

But hedging can also be imperfect. As another example, suppose you are a huge grapefruit producer. You want to hedge your profits by entering a forward contract to sell grapefruit (i.e. a contract to sell grapefruit at a pre-agreed price in the future), so that a bumper harvest world wide in August next year will not cause depressed prices to affect you. However, you feel that orange juice contracts are much more liquidly traded, whereas the forward market cannot accommodate the volume of grapefruit you wish to sell. You also believe (or have observed historically) that grapefruit prices and orange juice prices tend to move together (at least most of the time). So instead you sell futures on orange juice (i.e. you enter into an agreement on an exchange to sell a certain quantity of orange juice next August for a pre-agreed price).

There is a significant basis risk (i.e. risk due to hedging using related assets) in that there might be a blight in oranges but a bumper harvest for grapefruit. After all, the historical relation between harvests of grapefruit and oranges may change. In this case, your grapefruit harvest will be sold at reduced prices, and yet you will lose money on the orange juice futures you have sold, since orange juice prices will spike upwards sharply. That could very well lead to ruin, so you can see that hedging may not always be the perfect solution.

It is worth pointing out that hedging tends to involve simpler products than speculation, since here you are trying to generate cashflows which protect against movements of market variables that adversely affect you, based on your existing exposure. And such exposures tend to be the result of prior simpler arrangements.

**Speculation**

Speculation involves taking a position in the hope of making money. If I am a dollar hedger and think that the euro will rise, I can buy euros. However, if I were a euro investor, how
should I buy more euros? Perhaps, I could sell the dollar, or buy the euro by taking a long position (i.e. an agreement to buy the asset) in a 1-year EUR/USD forward contract. What differentiates me from the dollar hedger is that I have no need to buy euros, nor to sell any dollars.

No doubt huge risks can result from speculation. For instance, you could sell short a share (i.e. borrow a share you do not own to sell it) and be exposed to unlimited loss from any rises in its price. (This has nothing to do with derivatives. Going short a forward, however, involves derivatives.) But if you have bought an option, your losses are limited to the initial premium (since you are not obliged to enter the transaction at expiry).

This rather curiously takes us to the point that derivatives need not be risky in themselves. Indeed, many (but not all) retail notes are structured such that the investor’s principal (or at least part of it) is safe. Of course, an investor may at times want to surrender such protection in the hope of reaping even more significant gains. The next section will discuss structured notes, and the theme will be developed further in the book.

**Key Points**

- Derivatives are used for hedging and speculation.
- Hedging is aimed at protecting oneself from adverse market moves, but may not be perfect as the underlying and hedge may behave differently.
- Hedges can involve, for example, a forward (i.e. agreement to fix the price of a future transaction today), an option (i.e. the right but not obligation to enter into a future transaction), or even a knockout option (i.e. an option that can become worthless under certain conditions and is thus cheaper).
- Speculation is aimed at profiting by taking outright positions.
- Not all speculation involves derivatives (e.g. buying and selling shares); derivatives need not be more risky than cash positions (e.g. limited loss in option).

### 1.2 STRUCTURED NOTES

Structured products are bespoke instruments that enable investors to pursue strategies tailored to their market views. They allow an investor more control over the yield–risk tradeoff in his investment. In this section, I shall start by outlining the economic environment that encourages the growth of structured notes, and then explain them in more detail. The last decade of low interest rates (especially since 2001) has perhaps been a blessing to many (at least prior to the onset of the sub-prime crisis), but it has been a boon to others. In the days when interest rates were 7–8%, it was possible for one to earn a decent nominal yield by investing in a bond. But at 4–5%, this proposition looks much less attractive. (Figures 1.5 and 1.6 show the swap rates in the USA and Eurozone countries over the past decade.) Many pension funds pay on the basis of final salary schemes. At 7–8% nominal rates of return, their liabilities look much more manageable than at 4–5%. Indeed, many will have significant increases in their deficits unless they look to other sources of investments.

One can perhaps consider investment in equities. And indeed, there is some evidence that equities tend to outperform fixed income instruments in the long term. Figures 1.7 and 1.8 show the performances of the US and UK stock indices respectively, over the last two decades.
Figure 1.5 US swap rates for maturities 2y, 5y and 10y from 1994 to 2008. Notice how swap rates since 2001 have tended to be not much more than 5%, in contrast to the 7.5% around 2000 or even over 8% as in the mid-1990s.  
Source: Bloomberg

Alas, it need not always hold true. A case in point is Japan. As can be seen in Figure 1.9, at its peak on 29 December 1989, the Nikkei 225 index was at 38,916. And as of 30 December 2008 (19 years later), it is merely at 8,860. In Europe, pension funds are also precluded from investing too large a proportion of their assets in equities.

Besides, after the dotcom bubble burst in March 2000, and the further deterioration of the equity markets after the 11 September attacks, an alternative to equities might seem a reasonable avenue to diversify one’s portfolio. Although hedge funds have mostly filled this

Figure 1.6 Euro swap rates for maturities 2y, 5y and 10y from 1999 to 2008. Notice how swap rates have tended to be under 5% for most of the period.  
Source: Bloomberg
gap, the opaque nature of their operations and their restrictive practices (e.g. lock-in periods and potential restrictions on withdrawal, especially in times of crisis) leave much to be desired.

It should also come as no surprise that structured products have catered to other investment needs. Being bespoke instruments, structured products can be used to pursue strategies involving equities, interest rates, foreign exchange, commodities, credit or real estate. Perhaps

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**Figure 1.7** Level of S&P 500 index from 1990 to 2008. The S&P 500 index has had a meteoric rise from about 360 in January 1990 to over 1,500 by 2000, although there has been a period of decline from August 2000 to September 2003 to just over 800. Having climbed meaningful thereafter, there have been sharp declines in 2008.

*Source: Bloomberg*

**Figure 1.8** Level of FtSe 100 index from 1990 to 2008. The FtSe 100 has had a good run from 2,400 in January 1990 to a high of almost 6,900 in 2000. But like the S&P 500, the period until 2003 has been dismal, and the recovery since then has ended abruptly with the huge falls in 2008.

*Source: Bloomberg*
an investor has a view that US inflation will stay low as per historical levels between 1.5% and 4% (see Figure 1.10). Or perhaps another investor has a view that USD/JPY will stay within historical ranges (established over the last two decades) (see Figure 1.11).

The amount of risk in structured products is very much dependent on the terms of the instrument. On one extreme, it is possible to have a contingent liability instrument where losses are not limited to one’s initial investment. On the other hand, it is also possible to have notes where all (or part) of one’s principal is protected and would be repaid at expiry, notwithstanding market fluctuations. In this sense, structured products often have risk profiles that are between those of a bond and a stock.