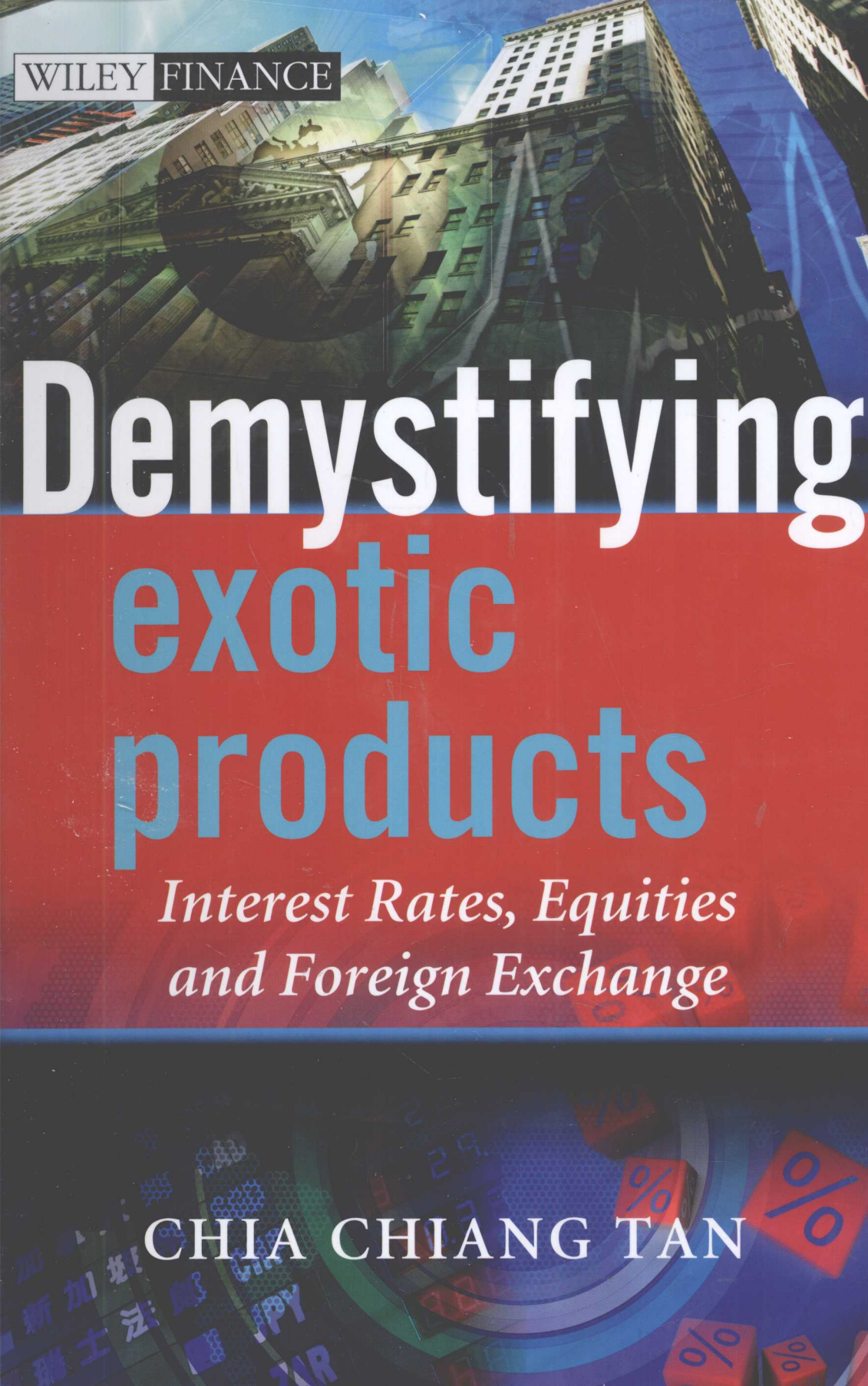
WILEY FINANCE
Demystifying
exotic
products
Interest Rates, Equities
and Foreign Exchange
CHIA CHIANG TAN

Demystifying Exotic Products

Interest Rates, Equities and Foreign Exchange

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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.

Alex Langnau
Global Head of Quantitative Analytics,
Allianz Investment Management, and
Visiting Scientist at the Ludwig-Maximillians University,
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.

Acknowledgements

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.

Notes

NOTE ON FX QUOTE STYLE

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 $E^Q[\bullet]$.

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.

Contents

1

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.

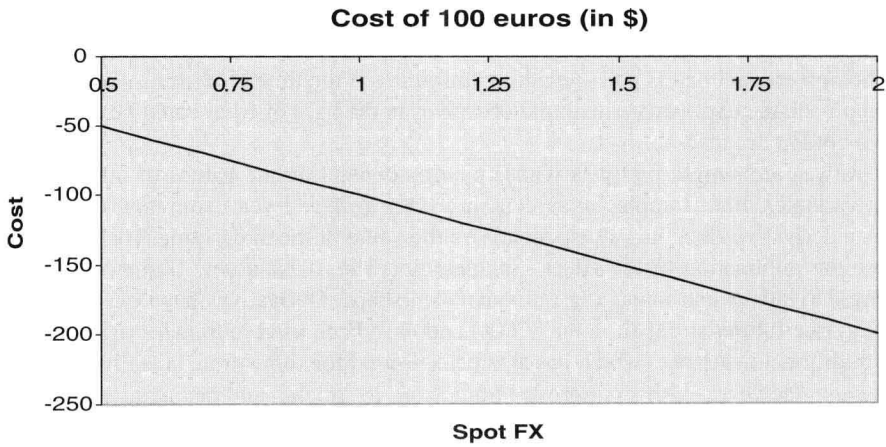

Figure 1.1 As the EUR/USD spot FX rate (1 year from today) varies from 0.5 to 2, the dollar cost of a €100 position varies from \$50 to \$200.

(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

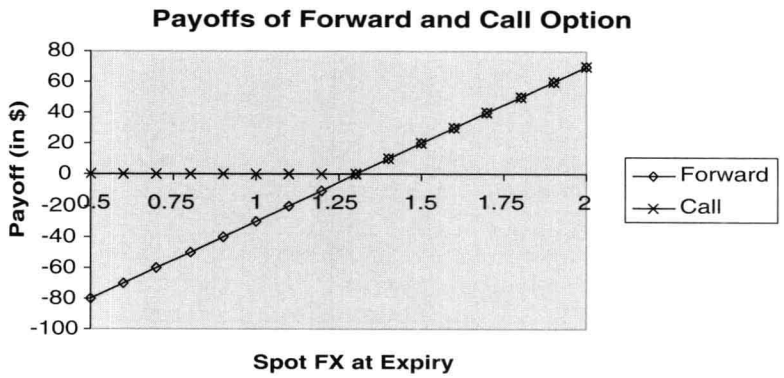

Figure 1.2 Dollar payoffs of a forward and a call option on EUR/USD based on different realised values of EUR/USD. Both the forward and the call option have increasing payoffs as EUR/USD increases but the payoff of the option does not go below zero when EUR/USD falls below 1.3.

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.

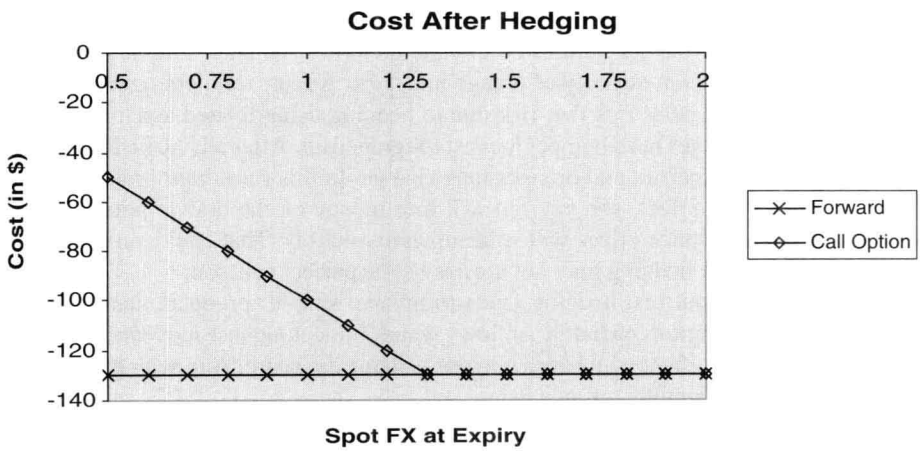

Figure 1.3 Resultant dollar payoffs when we superimpose the hedges (either forward or call option) on the short EUR/USD position (from the requirement to purchase €100). For the forward contract, the net effect is that you buy €100 at $130. For the call option, the net effect can lead to a cheaper cost of euro purchase if EUR/USD drops below 1.3.