Fundamentals of Futures and Options Markets

JOHN C. HULL SIRIMON TREEPONGKARUNA
RICHARD HEANEY DAVID PITT DAVID COLWELL

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PREFACE

In this Australasian edition of the classic text by Hull, we have aimed to produce a book even more suitable for use by students in the Australian region while maintaining the excellent pedagogical treatment provided in the original US version. In this adaptation of the original text, we have included Australian market conventions as they relate to options and futures markets. Often we have retained the US treatment in the text so as to maintain the international flavour of the book and to provide a contrast between the two different markets. Many Australian institutions and industry practices are referred to and described throughout the text. One of the many excellent features of the original text, namely the Business snapshots, have been developed further to include many relevant events from Australian practice. All chapters conclude with end of chapter exercises which have been graded in increasing order of difficulty as consolidate, development and extension. Exercises based on the updated Australian content have also been included where relevant. We have been careful to retain all the excellent qualities of the original version of this book which have made it so popular while making it more directly relevant to students studying in Australia and the region.

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John Hull was originally persuaded to write this book as colleagues who liked his other book *Options, Futures, and Other Derivatives*, found the material a little too advanced for their students. *Fundamentals of Futures and Options Markets* covers some of the same ground as *Options, Futures, and Other Derivatives*, but in a way that readers who have had limited training in mathematics find easier to understand. One important difference between the two books is that there is no calculus in this book. *Fundamentals* is suitable for undergraduate and graduate elective courses offered by business, economics, and other faculties. In addition, many practitioners who want to improve their understanding of futures and options markets will find the book useful.

The world has experienced a severe financial crisis and derivatives markets have been subject to a great deal of criticism. Students want to discuss this and t it is appropriate to talk about it at an early stage in a course on derivatives, hence included is a chapter on the crisis early in the book (Chapter 8). The chapter discusses the products that were created from subprime mortgages, what went wrong, and how future crises can be avoided.

Instructors can use this book in a many different ways. Some may choose to cover only the first 12 chapters, finishing with binomial trees. For those who want to do more, there are many different sequences in which chapters 13 to 25 can be covered. From Chapter 18 onward, each chapter has been

designed so that it is independent of the others and can be included in or omitted from a course without causing problems. It is useful finishing a course with Chapter 25, which students always find interesting and entertaining.

INCLUDED IN THIS EDITION

1.1 There is a chapter devoted to securitisation and the credit crisis (Chapter 8). The events in financial markets since the sixth edition was published make these topics particularly relevant for students.

1.2 A chapter devoted to employee stock options (Chapter 14). Changes in accounting rules have highlighted the importance of understanding how these options work and how they should be valued.

1.3 The material on value at risk is developed using an example involving real data taken from the credit crisis. Spreadsheets for the example are available on the author's website. Material on futures-style options, the use of clearinghouses for over-the-counter derivatives, and the VIX index has been included. These are topics that have become important in the last few years.

1.4 Key Australian content is included: fundamental theorem of asset pricing, GFC, CFD's., 90 day bank bill futures, stock options, focus on agricultural and energy derivatives, SPI futures, options on SPI futures and Australian Securities Exchange material

SUPPLEMENTS

Software

DerivaGem, Version 2.01, is included with this book and can be found on the supporting website to download (www.pearson.com.au/highered/hull). This consists of two Excel applications: the *Options Calculator* and the *Applications Builder*. The Options Calculator provides a user-friendly interface for valuing a wide range of options. The Applications Builder consists of a number of Excel functions from which users can build their own applications. It includes some sample applications and enables students to explore the properties of options and numerical procedures more easily. It also allows more interesting assignments to be designed.

Slides

A full set of Powerpoint slides have been developed to tie in closely with the text. These are fully customisable to meet individual teaching requirements.

Solutions Manual

The solutions manual provides answers to the practice and further questions within the text.

Test Bank

The test bank allows you to customise the bank of questions to meet your individual teaching needs and add/revise questions as needed. It provides a comprehensive set of multiple choice and short answer questions.

Quiz Answers

Answers to the quiz section at the end of each chapter which test the students understanding of the key concepts can also be found on the website

Spread sheets

Throughout the text data and Excel worksheets are referred to illustrate the theory, these are located on the supporting website.

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In adapting the original text to the Australian audience, we have to collect information about Australian market conventions from many sources. Hence, we would like to acknowledge Worapree Maneesoonthorn, Bruce Chen, Khulkanit Treepongkaruna, and Professor Phillip Gray, Department of Accounting and Finance, Monash University for their excellent assistance and support. Further, we would also like to thank Daniel Joseph and Kristye van de Geer from ASX for their insightful explanation in regard to Australian futures and options convention.

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CHAPTER

1

Introduction

LEARNING OBJECTIVES

1 To understand what a futures contract is
2 To gain exposure to the history behind futures in Australia and the US
3 To describe what an over-the-counter market is
4 To know what a forward contract is and how it relates to a futures contract
5 To describe option contracts, their basic characteristics and the way option prices vary
6 To gain exposure to the history behind options in Australia and the US and the different ways in which these are traded
7 To discuss the different functions that traders perform in futures, forwards and options markets
8 To discuss the role of hedgers
9 To describe what speculators do
10 To define what arbitrageurs do in markets
11 To identify the dangers inherent in derivatives trading

Introduction

Derivatives markets have become increasingly important in the world of finance and investments. It has become essential for all finance professionals to understand how these markets work, how they can be used and what determines prices in them. This book addresses these issues.

The world has just experienced a severe credit crisis and the worst recession in several generations. The derivatives that were created from residential mortgages in the United States played a role in the crisis. Chapter 8 looks at the nature of these derivatives, examines why some investors misjudged their risks and considers how similar crises can be avoided in the future.

In this opening chapter we take a first look at some of the futures, forwards and options markets in Australia and in the US. We examine their history and provide an introduction to how they are used by hedgers, speculators and arbitrageurs.

LO 1

To understand what a futures contract is

1.1 Futures contracts

A **futures contract** is an agreement to buy or sell an asset at a certain time in the future for a certain price. There are many exchanges throughout the world trading futures contracts. The Chicago Board of Trade, the Chicago Mercantile Exchange and the New York Mercantile Exchange have merged to form the CME Group (<www.cmegroup.com>). Other large exchanges include NYSE Euronext (<www.euronext.com>), Eurex (<www.eurexchange.com>), BM&FBOVESPA (<www.bmfbovespa.com.br>) and the Tokyo Financial Exchange (<www.tfx.co.jp>). The key exchanges in our region include the Korea Exchange (<eng.krx.co.kr>), the National Stock Exchange of India (<www.nseindia.com>), with considerable trading evident in the Tokyo Financial Exchange (<www.tfx.co.jp>), the Australian Securities Exchange (ASX) (<www.asx.com.au>) and the Singapore Exchange (<www.sgx.com>). A table at the end of this book gives a more complete list.

Futures exchanges allow people who want to buy or sell assets in the future to trade with each other. The 90-day bank accepted bill futures contract is one of the most heavily traded of the Australian futures contracts. The face value of the underlying bills covered by one contract is $1 000 000 and the bills delivered under the contract have 90 days to maturity. Say that in March a trader in Sydney contacts a broker with instructions to buy 100 90-day bank bill futures contracts expiring in June. The broker would immediately communicate the client's instructions to the Australian Securities Exchange. At about the same time, say that another trader in Perth has instructed their broker to sell 100 90-day bank bill futures contracts expiring in June. These instructions would also be passed on to the Australian Securities Exchange. A price would be determined and the deal would be done.

The trader in Sydney who agreed to buy has what is termed a *long futures position*; the trader in Perth who agreed to sell has what is termed a *short futures position*. The price is known as the **futures price**. We will suppose the price is 95.00 (giving an implicit yield of 5.00% per annum). This price, like any other price, is determined by the laws of supply and demand. If at

a particular time more people wish to sell June 90-day bank bills than to buy them, the price goes down. New buyers will then enter the market so that a balance between buyers and sellers is maintained. If more people wish to buy June 90-day bank bills than to sell, the price goes up—for similar reasons.

Issues such as margin requirements, daily settlement procedures, trading practices, commissions, bid–offer spreads and the role of the exchange clearinghouse will be discussed in Chapter 2. For the time being, we can assume that the end result of the events just described is that the trader in Sydney has agreed to buy $100 million worth of 90-day bank bills in June and the trader in Perth has agreed to sell $100 million worth of 90-day bank bills in June. Both sides have entered into a binding contract. The details for one futures contract are illustrated in Figure 1.1.

A futures contract (assuming it is held to maturity)

March: Trader takes a long position in a June futures contract on 90-day bank accepted bills at 95.00. This implies a yield of 5% per annum is to be used to value the futures contract.

↓

June: Trader must buy 90-day bank accepted bills with total face value of $1 000 000 at a yield of 5% per annum. The futures price that would be paid for the bills is:

$$\text{Futures price} = \frac{\$1\,000\,000}{1 + \frac{5}{100} \times \frac{90}{365}} = \$987\,821.38$$

A futures price can be contrasted with the **spot price**. The spot price is for immediate, or almost immediate, delivery. The futures price is the price for delivery at some time in the future. The two are not usually equal. As we will see in later chapters, the futures price may be greater than or less than the spot price.

1.2 History of futures markets

LO 2

To gain exposure to the history behind futures in Australia and the US

Futures markets can be traced back to the Middle Ages. They were originally developed to meet the needs of farmers and merchants. Consider the position of a farmer in April of a certain year who will harvest a known amount of grain in June. There is uncertainty about the price the farmer will receive for the grain. In years of scarcity it might be possible to obtain relatively high prices, particularly if the farmer is not in a hurry to sell. On the other hand, in years of oversupply the grain might have to be disposed of at fire-sale prices. The farmer and the farmer's family are clearly exposed to a great deal of risk.

Consider next a company that has an ongoing requirement for grain. The company is also exposed to price risk. In some years an oversupply situation may create favourable prices; in other years scarcity may cause the prices to be exorbitant. It can make sense for the farmer and the company to get together in April (or even earlier) and agree on a price for the farmer's production of grain in June. This involves them negotiating a type of futures contract. The contract provides a way for each side to eliminate the risk it faces because of the uncertain future price of grain.

We might ask what happens to the company's requirements for grain during the rest of the year. Once the harvest season is over, the grain must be stored until the next season. In undertaking this storage, the company does not bear any price risk, but does incur the costs of storage. If the farmer or some other person stores the grain, the company and the storer both face risks associated with the future grain price, and again there is a clear role for futures contracts.

THE AUSTRALIAN SECURITIES EXCHANGE

The Australian Securities Exchange was created in 2006 with the merger of the Australian Stock Exchange and the Sydney Futures Exchange. Futures contracts were initially traded solely on the Sydney Futures Exchange (SFE). In the 1990s the Australian Stock Exchange introduced low exercise price options, which essentially replicated the individual share futures contract that was trading on the SFE. The result was an increase in the level of competition in derivatives markets in Australia for a period, though this ceased with the creation of the Australian Securities Exchange.

The Sydney Futures Exchange began trading as the Sydney Greasy Wool Futures Exchange in 1960 and by the middle of the 1960s it was the world's leading futures market. The range of futures contracts offered on the exchange expanded over time to include gold futures, and in 1979 the Sydney Futures Exchange was the first non-US exchange to introduce a financial futures contract, the 90-day bank accepted bill futures contract. This contract is still one of the most heavily traded contracts offered by the Australian Securities Exchange. The share price index futures contract has also been popular. Recent additions to the portfolio of futures contracts available to Australian traders include contracts for difference and electricity futures contracts. The development of the Australian market is a recent phenomenon when compared with the major US markets.

THE CHICAGO BOARD OF TRADE

The Chicago Board of Trade (CBOT) was established in 1848 to bring farmers and merchants together. Initially, its main task was to standardise the quantities and qualities of the grains that were traded. Within a few years, the first futures-type contract was developed. It was known as a *to-arrive contract*. Speculators soon became interested in the contract and found trading the contract to be an attractive alternative to trading the grain itself. The Chicago Board of Trade now offers futures contracts on many different underlying assets, including corn, oats, soybeans, soybean meal, soybean oil, wheat, Treasury bonds and Treasury notes.

THE CHICAGO MERCANTILE EXCHANGE

In 1874 the Chicago Produce Exchange was established, providing a market for butter, eggs, poultry and other perishable agricultural products. In 1898 the butter and egg dealers withdrew from the exchange to form the Chicago Butter and Egg Board. In 1919, this was renamed the Chicago Mercantile Exchange (CME) and was reorganised for futures trading. Since then, the exchange has provided a futures market for many commodities, including pork bellies (1961), live cattle (1964), live hogs (1966) and feeder cattle (1971). In 1982 it introduced a futures contract on the Standard & Poor's (S&P) 500 Stock Index.

The Chicago Mercantile Exchange started futures trading in foreign currencies in 1972. The currency futures traded now include the British pound, the Canadian dollar, the Japanese yen, the Swiss franc, the Australian dollar, the Mexican peso, the Brazilian real, the South African rand, the New Zealand dollar, the Russian rouble and the euro. The Chicago Mercantile Exchange trades the very popular Eurodollar futures contract. (As later chapters will explain, this is a contract on the future value of a short-term interest rate.) It has also introduced futures contracts on weather and real estate.

ELECTRONIC TRADING

Traditionally, futures contracts have been traded using what is known as the **open-outcry system**. This involves traders physically meeting on the floor of the exchange, known as the 'trading pit' and shouting and/or using a complicated set of hand signals to indicate the trades they would like to carry out. In the example we considered earlier, one floor trader would represent the investor in Sydney who wanted to buy 90-day bank bills in June and another floor trader would represent the investor in Perth who wanted to sell 90-day bank bills in June.

Exchanges are increasingly replacing the open-outcry system with **electronic trading**. Indeed, the Australian Securities Exchange relies entirely on electronic trading. This involves traders entering their required trades at a keyboard and a computer being used to match buyers and sellers. Most futures exchanges throughout the world are entirely electronic. Electronic trading has led to a growth in algorithmic trading, also known as black-box, automated, high-frequency or robo trading. This involves the use of computer programs to initiate trades, often without human intervention.

1.3 The over-the-counter market

LO 3

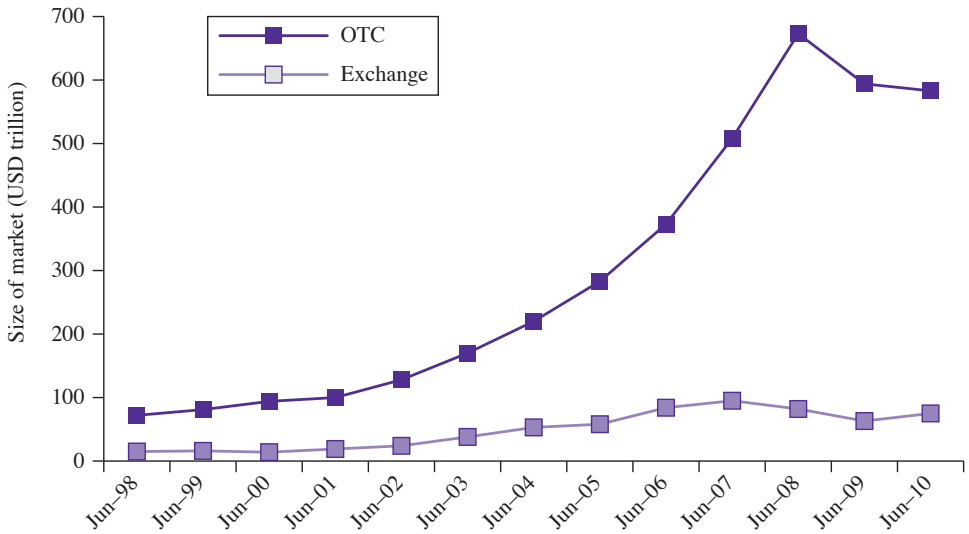
To describe what an over-the-counter market is

Not all trading of derivatives is done on exchanges. What is known as the **over-the-counter** or OTC market is an important alternative to exchanges. It is a telephone- and computer-linked network of dealers. Trades are done over the phone. One side to the transaction is usually a trader working for a financial institution. The other side is likely to be either a trader working for another financial institution or a corporate treasurer or fund manager. Financial institutions often act as market makers for the more commonly traded instruments. This means that they are always prepared to quote both a bid price (a price at which they are prepared to buy) and an offer price (a price at which they are prepared to sell).

Telephone conversations in the over-the-counter market are usually taped. If there is a dispute about what was agreed, the tapes are replayed to resolve the issue. Trades in the over-the-counter market are typically much larger than trades in the exchange-traded market. A key advantage of the over-the-counter market is that the terms of a contract do not have to be those specified by an exchange. Market participants are free to negotiate any mutually attractive deal. A disadvantage is that there is usually some credit risk in an over-the-counter trade (that is, there is a small risk that the contract will not be honoured) though banks have systems in place to manage individual and corporate credit risk of this nature. As we shall see in the next chapter, exchanges have organised themselves to eliminate virtually all credit risk.

Both the over-the-counter and the exchange-traded market for derivatives are huge. Although the statistics that are collected for the two markets are not exactly comparable,

FIGURE 1.2 **Size of over-the-counter and exchange-traded derivatives markets**



it is clear that the over-the-counter market is much larger than the exchange-traded market. The Bank for International Settlements (<www.bis.org>) started collecting statistics on the markets in 1998. Figure 1.2 compares: (a) the estimated total principal amounts underlying transactions that were outstanding in the over-the-counter markets between 1998 and 2010, and (b) the estimated total value of the assets underlying exchange-traded contracts during the same period. Using these measures, the size of the over-the-counter market was $583 trillion in June 2010 and that of the exchange-traded market was $75 trillion at this time.

In interpreting these numbers we should bear in mind that the principal underlying an over-the-counter transaction is not the same as its value. An example of an over-the-counter contract is an agreement to buy 100 million US dollars (USD) with Australian dollars (AUD) at a predetermined exchange rate in one year. The total principal amount underlying this transaction is USD 100 million. However, the value of the contract might be only USD 1 million. The Bank for International Settlements estimated the gross market value of all OTC contracts outstanding in June 2010 to be about USD 25 trillion.[1]

LO 4

To know what a forward contract is and how it relates to a futures contract

1.4 Forward contracts

A forward contract is similar to a futures contract in that it is an agreement to buy or sell an asset at a certain time in the future for a certain price. But, whereas futures contracts are traded on exchanges, forward contracts trade in the over-the-counter market.

Forward contracts on foreign exchange are very popular. Most large banks employ both spot and forward foreign exchange traders. Spot traders are trading a foreign currency for

1 A contract that is worth USD 1 million to one side and –USD 1 million to the other side would be counted as having a gross market value of USD 1 million.

TABLE 1.1

Spot, forward margins quoted for the USD exchange rate and calculated forward rates, 10 January 2011 (AUD = Australian dollar; USD = US dollar; quote is number of USD per AUD)

	BID MARGIN	OFFER MARGIN	BID RATE	OFFER RATE
SPOT			0.9934	0.9937
1-MONTH FORWARD	40.80	40.50	0.98932	0.98965
3-MONTH FORWARD	111.70	111.30	0.98223	0.98257
6-MONTH FORWARD	225.30	224.10	0.97087	0.97129

almost immediate delivery.[2] Forward traders are trading for delivery at a future time. Table 1.1 provides the quotes on the exchange rate between the Australian dollar (AUD) and the US dollar (USD) that might have been made by a large international bank on 10 January 2011. It should be noted that foreign currency traded at the spot rate is to be delivered in two clear business days after the date the rate is quoted. Forward contracts refer to delivery after two clear business days following the date the rate is quoted. Also note that the forward rates are generally quoted as forward margins. Both bid and offer forward margins are reported in the second and third columns of Table 1.1 respectively. These margins are combined with the spot rate to give the forward rate. As the interest rates are higher in Australia than in the United States on 10 January 2011, the forward margins are deducted from the spot rate. If they were lower the forward margins would be added.

The calculated forward rates appear in the fourth and fifth columns of Table 1.1. The quotes are expressed in terms of the number of USD per AUD. The first row indicates that the bank is prepared to buy AUD in the spot market (i.e. for delivery within two clear business days following quotation) at the rate of USD 0.9934 per AUD and sell in the spot market at USD 0.9937 per AUD. The second row indicates that the bank is prepared to buy AUD in one month at USD 0.98932 per AUD and sell in one month at USD 0.98965 per AUD; the third row indicates that the bank is prepared to buy AUD in three months at USD 0.98223 per AUD and sell in three months at USD 0.98257 per AUD; and so on.

The quotes are for very large transactions. (As anyone who has travelled abroad knows, retail customers face much larger spreads between bid and offer quotes than those in Table 1.1.) After examining the quotes in Table 1.1, a large corporation might agree to sell AUD 100 million in six months for USD 97.087 million to the bank as part of its hedging program.

There is a relationship between the forward price of a foreign currency, the spot price of the foreign currency, domestic interest rates and foreign interest rates. This is explained in Chapter 5.

1.5 Options

LO 5

To describe option contracts, their basic characteristics and the way option prices vary

Options are traded both on exchanges and in the over-the-counter markets. There are two types of option: calls and puts. A **call option** gives the holder the right to buy an asset by a certain date for a certain price. A **put option** gives the holder the right to sell an asset by a

2 In Australia, if delivery of the currency occurs within two clear business days from the transaction date then the transaction is regarded as a trade in the spot market.

TABLE 1.2 Margin prices of options on BHP, 7 January 2011; stock price = $44.60

	CALLS			PUTS		
STRIKE PRICE ($)	24 FEB. 2011	24 MAR. 2011	28 APR. 2011	24 FEB. 2011	24 MAR. 2011	28 APR. 2011
43.500	2.530	2.780	3.185	0.660	1.095	1.430
44.000	2.155	2.430	2.890	0.760	1.265	1.610
44.500	1.840	2.150	2.555	0.940	1.455	1.810
45.000	1.520	1.835	2.260	1.135	1.675	2.030
45.500	1.240	1.570	2.010	1.365	1.910	2.270
46.000	1.010	1.310	1.755	1.630	2.180	2.525

certain date for a certain price. The price in the contract is known as the **exercise price** or the **strike price**; the date in the contract is known as the **expiration date** or the **maturity date**. A **European option** can be exercised only on the maturity date; an **American option** can be exercised at any time during its life.

It should be emphasised that an option gives the holder the right to do something. The holder does not have to exercise this right. This fact distinguishes options from futures (or forward) contracts. The holder of a long futures contract is committed to buying an asset at a certain price at a certain time in the future. By contrast, the holder of a call option has a choice as to whether to buy the asset at a certain price at a certain time in the future. It costs nothing (except for margin requirements, which will be discussed in Chapter 2) to enter into a futures contract. By contrast, generally an investor must pay an up-front price, known as the *option premium*, for an option contract.

The largest exchange in the world for trading stock options is the Chicago Board Options Exchange (CBOE; <www.cboe.com>). Trading in exchange-traded options also takes place on the ASX. Table 1.2 gives the margin prices[3] for some of the options trading on BHP on 7 January 2011. The quotes are taken from the ASX website. The BHP stock price at the time of the quotes was $44.600. The option strike prices are $43.500, $44.000, $44.500, $45.000, $45.500 and $46.000. The contracts expire on 24 February 2011, 24 March 2011 and 28 April 2011 respectively.

Table 1.2 illustrates a number of properties of options. The price of a call option decreases as the strike price increases and the price of a put option increases as the strike price increases. Both types of option tend to become more valuable as their time to maturity increases. These properties of options will be discussed further in Chapter 10.

Suppose an investor instructs a broker to buy one March call option contract on BHP with a strike price of $44.50. The broker will relay these instructions to a trader at the ASX. This trader will then find another trader who wants to sell one March call contract on BHP with a strike price of $44.50 and a price will be agreed. For the purposes of our example,

3 This is a theoretical value of the option. It is calculated by the Australian Clearing House and is used to assess margin obligations. While the mid-point of the bid and offer price is generally used as an indicative trading price, market activity is quite low in January and so the margin prices are used as a proxy.

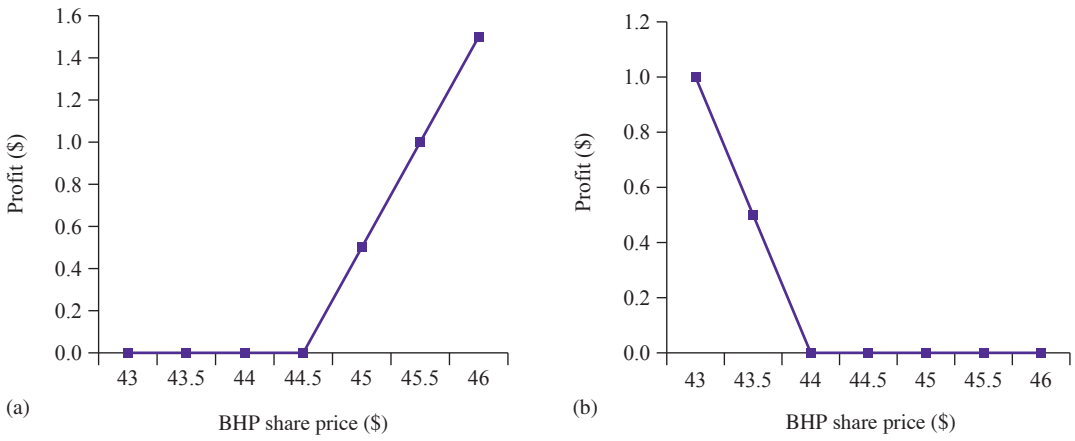
we ignore the bid–offer spread and assume that the price is $2.150, as indicated in Table 1.2. This is the price for an option to buy one share. In Australia, an option contract is a contract to buy or sell 100 shares and this applies to most shares traded on the ASX, including BHP. Therefore the investor must arrange for $215 to be remitted to the exchange through the broker. The exchange will then arrange for this amount to be passed on to the party on the other side of the transaction.

In our example the investor has obtained at a cost of $215 the right to buy 100 BHP shares for $44.50 each. The party on the other side of the transaction has received $215 and has agreed to sell 100 BHP shares for $44.50 per share if the investor chooses to exercise the option. If the price of BHP does not rise above $44.50 before 24 March 2011, the option is not exercised and the investor loses $215.[4] But if the BHP share price does well and the option is exercised when it is $50.00, the investor is able to buy 100 shares at $44.50 per share when they are worth $50.00 per share. This leads to a gain of $550, or $335 when the initial cost of the options is taken into account.

An alternative trade for the investor would be the purchase of one April put option contract with a strike price of $44.00. From Table 1.2 we see that this would cost 100 × 1.610, or $161. The investor would obtain the right to sell 100 BHP shares for $44 per share prior to 28 April 2011. If the BHP share price stays above $44, the option is not exercised and the investor loses $161. But if the investor exercises when the stock price is $40, he or she makes a gain of $400 by buying 100 BHP shares at $40 and selling them for $44. The net profit after the cost of the option is taken into account, but excluding transaction costs and taxes, is $239.

The stock options trading on the ASX are American (i.e. they can be exercised at any time before expiration). If we assume for simplicity that they are European, so that they can be exercised only at maturity, the investor's payoff as a function of the final stock price for the two trades we have considered is shown in Figure 1.3.

Net profit from: (a) purchasing a BHP March call option contract, consisting of 100 BHP shares, with a strike price of $44.50, and (b) purchasing a BHP April put option contract, consisting of 100 BHP shares, with a strike price of $44.00 FIGURE 1.3



4 This ignores other costs of completing the transaction including brokerage costs and taxes.