CHAPTER SEVEN

Option Basics

The shift toward options as the center of gravity of finance [. . .]
Merton H. Miller (1923–2000) [666]

Options grant their holder the right to buy or sell some **underlying asset**. Options are therefore **contingent claims** or **derivative securities** because their value depends on that of the underlying asset. Besides being one of the most important classes of financial instruments, options have wide-ranging applications in finance and beyond. As far as explaining empirical data goes, the option pricing theory ranks as the most successful theory in finance and economics [766].

7.1 Introduction

There are two basic types of options: **calls** and **puts**. More complex instruments can often be decomposed into a package of calls and puts. A call option gives its holder the right to buy a specified number of the underlying asset by paying a specified **exercise price** or **strike price**. A put option gives its holder the right to sell a specified number of the underlying asset by paying a specified strike price. The underlying asset may be stocks, stock indices, options, foreign currencies, futures contracts, interest rates, fixed-income securities, mortgages, winter temperatures, and countless others [54, 346, 698]. When an option is embedded, it has to be traded along with the underlying asset.

The one who issues an option is called a **writer**. To acquire the option, the holder pays the writer a **premium**. When a call is **exercised**, the holder pays the writer the strike price in exchange for the stock, and the option ceases to exist. When a put is exercised, the holder receives from the writer the strike price in exchange for the stock, and the option ceases to exist. An option can be exercised before the expiration date, which is called **early exercise**. It can also be sold at any trading date before the expiration date.

American and **European options** differ in when they can be exercised. American options can be exercised at any time up to the expiration date, whereas European options can be exercised only at expiration.[1] An American option is worth at least as much as an otherwise identical European option because of the early exercise feature.

Many strategies and analysis in the book depend on taking a **short position**. In stocks, short sales involve borrowing stock certificates and buying them back later; in

short, selling what one does not own precedes buying. The short seller is apparently betting that the stock price will decline. Note that borrowed shares have to be paid back with shares, not cash. The short seller does not receive cash dividends; in fact, the short seller must make matching dividend payments to the person to whom the shares were sold. Every dividend payout hence reduces a short seller's return.

It is easier to take a short position in derivatives. All one has to do is to find an investor who is willing to buy them, that is, to be **long** the derivatives. For derivatives that do not deliver the underlying asset or those that are mostly settled by taking offset positions, their outstanding contracts may cover many times the underlying asset [60].

For the rest of this chapter, C denotes the call value, P the put value, X the strike price, S the stock price, and D the dividend. Subscripts are used to differentiate or emphasize times to expiration, stock prices, or strike prices. The notation $\mathrm{PV}(x)$ indicates the PV of x dollars at expiration.

7.2 Basics

An option does not oblige its holder to exercise the right. An option will hence be exercised only when it is in the best interest of its holder to do so. Clearly a call will be exercised only if the stock price is higher than the strike price. Similarly, a put will be exercised only if the stock price is less than the strike price. The value or **payoff** of a call at expiration is therefore $C = \max(0, S - X)$, and that of a put at expiration is $P = \max(0, X - S)$ (see Fig. 7.1). Payoff, unlike profit, does not account for the initial cost. For example, the payoff of a long position in stock is S, and the payoff of a short position in stock is $-S$ (see Fig. 7.2). At any time t before the expiration date,

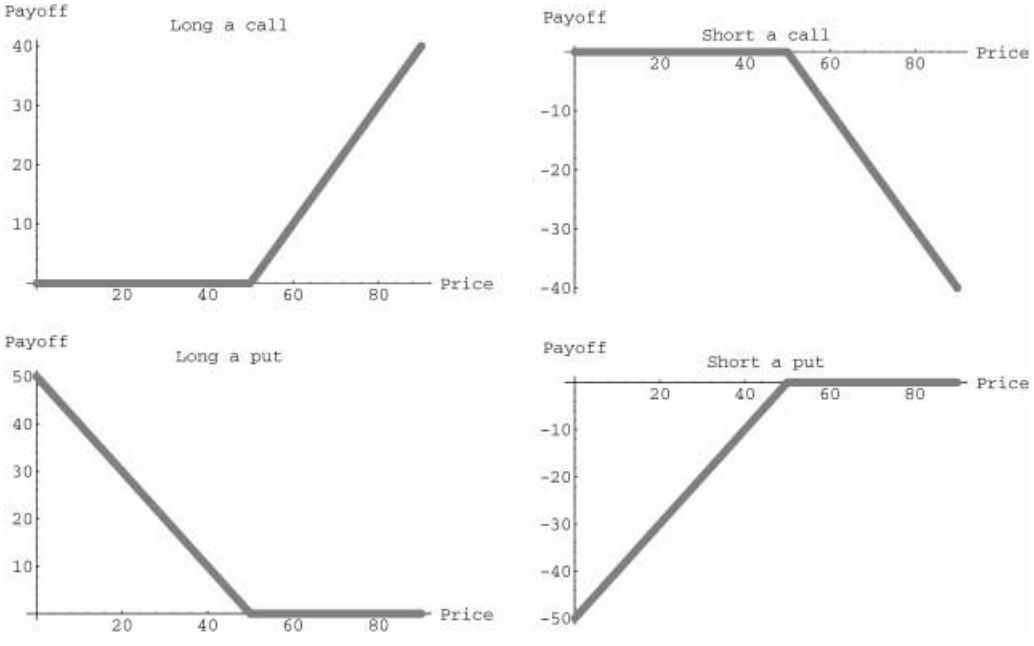

Figure 7.1: Option payoffs: the option payoffs at expiration with a strike price of 50.

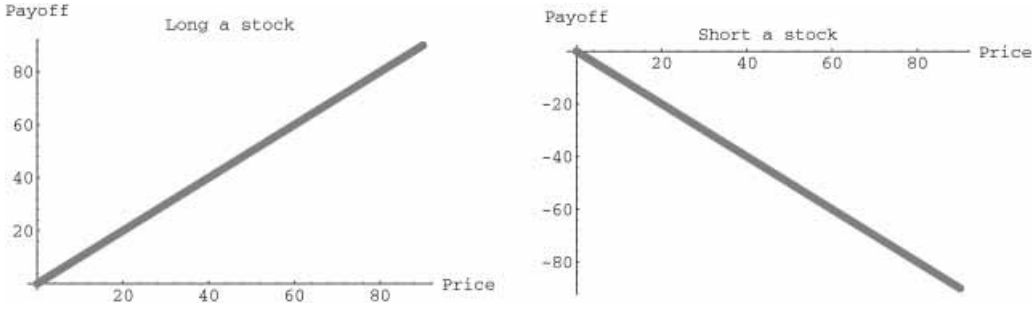

Figure 7.2: Payoff of stock: the payoffs of long and short positions in stock.

we call $\max(0, S_t - X)$ the **intrinsic value** of a call and $\max(0, X - S_t)$ the intrinsic value of a put. The part of an option's value above its intrinsic value is called its **time value** and represents the possibility of becoming more valuable before the option expires. The option premium thus consists of the intrinsic value and the time value. A call is said to be **in the money** if $S > X$, **at the money** if $S = X$, and **out of the money** if $S > X$. Similarly, a put is said to be **in the money** if $S < X$, **at the money** if $S = X$, and **out of the money** if $S > X$. Options that are in the money at expiration should be exercised. Surprisingly, more than 10% of option holders let in-the-money options expire worthless [340]. Although an option's terminal payoff is obvious, finding its value at any time before expiration is a major intellectual breakthrough. Figure 7.3 plots the values of put and call before expiration.

7.3 Exchange-Traded Options

Puts and calls first appeared in 1790. (Aristotle described a kind of call in *Politics* [29, Book 2, Chapter 11].) However, before 1973, options were traded in **over-the-counter markets** in which financial institutions and corporations traded directly with one another. The main distinction of over-the-counter options is that they are customized. Today, over-the-counter options are most popular in the area of foreign currencies and interest rates.

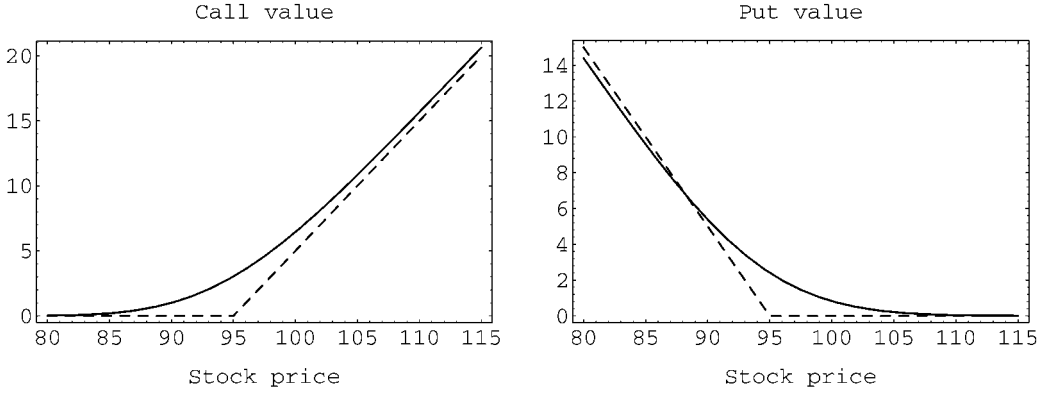

Figure 7.3: Values of call and put before expiration. Plotted are the general shapes of call and put values as functions of the stock price before expiration. Dashed lines denote the option values at expiration.

The Chicago Board Options Exchange (CBOE) started the options trading on April 26, 1973. Since then options have been traded in many exchanges such as the American Stock Exchange (AMEX) and the Philadelphia Stock Exchange (PHLX). **Exchange-traded options** standardize the terms of option contracts, create centralized trading and price dissemination facilities, and introduce the Options Clearing Corporation (OCC), all of which serve to promote an active secondary market. The term **listed option** is also used to refer to an exchange-traded option.

Terms on the exchange-traded stock options govern the expiration dates and the strike prices. The strike prices are centered on the current price of the underlying stock with fixed increments that depend on the price of the stock. Typical increments are $\$2_{1/2}$ for a stock price less than \$25 per share, \$5 for a stock price between \$25 and \$200 per share, and \$10 for a stock price over \$200 per share. A stock typically has options outstanding expiring at three expiration dates. The exchange also limits the maximum number of options an individual can take on one side of the market. Exchange-traded stock options are American.

Exchange-traded stock options are not **cash dividend protected** (or simply **protected**). This means that the option contract is not adjusted for cash dividends. As the stock price typically falls by the amount roughly equal to the amount of the cash dividend as it goes ex-dividend, dividends are detrimental for calls. The converse is true for puts. However, options are adjusted for stock splits. After an n-for-m stock split, the strike price is only m/n times its previous value, and the number of shares covered by one contract becomes n/m times its previous value. Exchange-traded stock options are also adjusted for stock dividends. Unless stated otherwise, options are assumed to be unprotected. Figure 7.4 shows a small sample of listed stock options.

EXAMPLE 7.3.1 For an option to buy 100 shares of a company for \$50 per share, a 2-for-1 split would change the term to a strike price of \$25 per share for 200 shares.

A contract normally covers 100 shares of stock. Option prices are quoted per unit of the underlying asset. For instance, the Merck July 35 call closed at $9_{1/2}$ on March 20, 1995, by Fig. 7.4. The total cost of the call was \$950.

For exchange-traded options, an option holder can **close out** or **liquidate** the position by issuing an **offsetting order** to sell the same option. Similarly, an option writer can close out the position by issuing an offsetting order to buy the same option. This is called **settled by offset**, made possible by the OCC. The **open interest** is the total number of contracts that have not been offset, exercised, or allowed to expire – in short, the total number of long (equivalently, short) positions.

7.4 Basic Option Strategies

Option strategies involve taking positions in options, the underlying assets, and borrowing or lending. For example, six positions were mentioned before: long stock, short stock, long call, short call, long put, and short put. A strategy can be **bullish**, **bearish**, or **neutral** in terms of market outlook, it can be **aggressive**, **defensive**, or virtually **riskless** in terms of risk posture, and it can be designed to profit in volatile or calm markets. For example, buying a stock is a bullish and aggressive strategy, bullish because it profits when the stock price goes up and aggressive because

			—Call—		—Put—	
Option	*Strike*	*Exp.*	*Vol.*	*Last*	*Vol.*	*Last*
			...			
Exxon	60	Apr	1053	5 1/2	1000	3/16
65	65	Apr	951	1 5/16	830	11/16
65	65	May	53	1 7/16	10	1 1/16
65	65	Oct	32	2 3/4	...	...
65	70	Jul	2	1/4	40	5 1/4
			...			
Merck	30	Jul	328	15 1/4	...	...
44 1/2	35	Jul	150	9 1/2	10	1/16
44 1/2	40	Apr	887	4 3/4	136	1/16
44 1/2	40	Jul	220	5 1/2	297	1/4
44 1/2	40	Oct	58	6	10	1/2
44 1/2	45	Apr	3050	7/8	100	1 1/8
44 1/2	45	May	462	1 3/8	50	1 3/8
44 1/2	45	Jul	883	1 15/16	147	1 3/4
44 1/2	45	Oct	367	2 3/4	188	2 1/16
			...			
Microsoft	55	Apr	65	16 3/4	52	1/8
71 1/8	60	Apr	556	11 3/4	39	1/8
71 1/8	65	Apr	302	7	137	3/8
71 1/8	65	Jul	93	9	15	1 1/2
71 1/8	65	Oct	34	10 5/8	9	2 1/4
71 1/8	70	Apr	1543	3 1/8	162	1 1/2
71 1/8	70	May	42	4 1/4	2	2 1/8
71 1/8	70	Jul	190	5 3/4	61	3
71 1/8	70	Oct	94	7 1/2	1	4
			...			

Figure 7.4: Options quotations. In August 2000, the *Wall Street Journal* started quoting stocks traded on the New York Stock Exchange, the Nasdaq National Market, and the AMEX in decimals. All three exchanges are expected to convert to the decimal system by April 2001. Source: *Wall Street Journal*, March 21, 1995.

the investor runs the risk of maximum loss, dollar for dollar, if the stock goes down. More aggressive strategies include buying stocks on margin and buying options. For instance, the Exxon April 60 call allows the holder to control a $65 stock for a mere $5.5 (see Fig. 7.4). Selling stocks short, on the other hand, is aggressive but bearish. In **covered** positions, some securities protect the returns of others. There are three basic kinds of covered positions: **hedge**, **spread**, and **combination**.

➤ **Exercise 7.4.1** How would you characterize buying a call in terms of market outlook and risk posture?

7.4.1 Hedge

A **hedge** combines an option with its underlying stock in such a way that one protects the other against loss. A hedge that combines a long position in stock with a long put

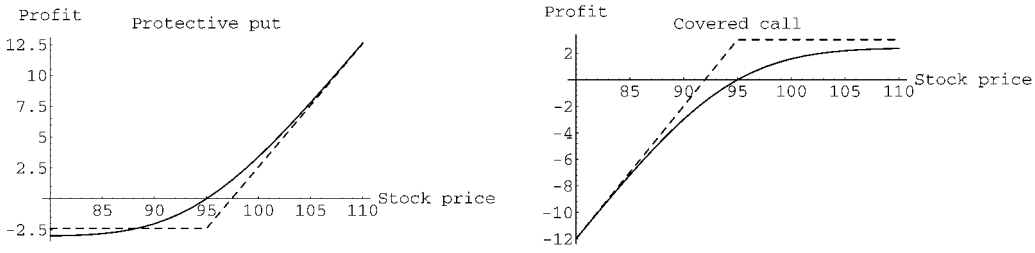

Figure 7.5: Profits of protective put and covered call. The strike price and the current stock price are both \$95. The dashed lines represent the positions' profits at expiration. A **profit diagram** does not take into account the time value of the money used in setting up the position.

is called a **protective put**. A hedge that combines a long position in stock with a short call is called a **covered call** (see Fig. 7.5). Covered calls may be the most common option strategy used by institutional investors to generate extra income in a flat market. Because both strategies break even only if the stock price rises, their market outlook is bullish. They are also defensive: The investor owns the stock anyway in a covered call, and the protective put guarantees a minimum value for the portfolio. A **reverse hedge** is a hedge in the opposite direction such as a short position in stock combined with a short put or a long call.

Writing a **cash-secured put** means writing a put while putting aside enough money to cover the strike price if the put is exercised. The payoff is similar to that of a covered call. The maximum profit is $X - [\,\mathrm{PV}(X) - P\,]$, and the maximum loss is $P - \mathrm{PV}(X)$, which occurs when the stock becomes worthless. A **ratio hedge** combines two short calls against each share of stock. It profits as long as the stock price does not move far in either direction. See Fig. 7.6 for illustration.

➤ **Exercise 7.4.2** Verify the maximum profit of the cash-secured put.

➤ **Exercise 7.4.3** Both a protective put on a diversified portfolio and a fire insurance policy provide insurance. What is the essential difference between them?

➤ **Exercise 7.4.4** Start with \$100 and put $100/(1+r)$ in the money market earning an annual yield of r. The rest of the money is used to purchase calls. (1) Figure out

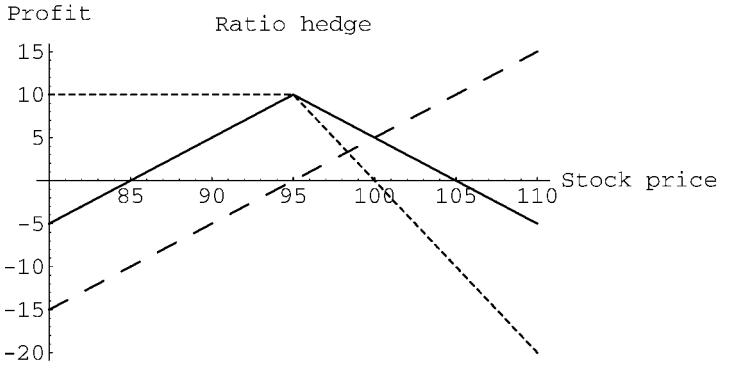

Figure 7.6: Profit of ratio hedge. The solid line is the profit diagram of a ratio hedge at expiration with a strike price of \$95 and a current stock price of \$95. The dashed line represents the profit diagram of the stock, and the dotted line represents the profit diagram of the option.

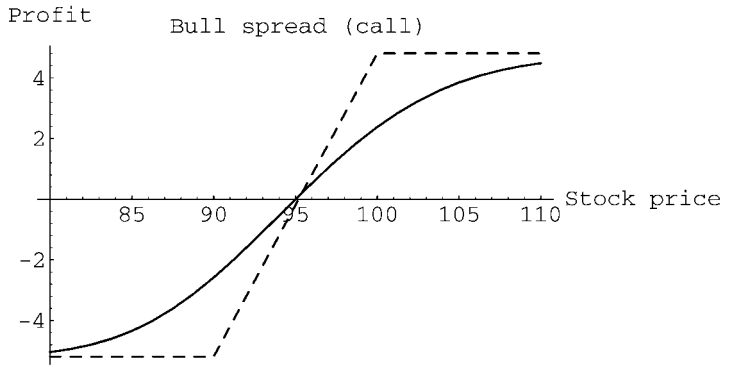

Figure 7.7: Profit of bull call spread. Plotted is the profit diagrams of a bull call spread at expiration (dashed line) and at 1 month before expiration (solid curve). Both the strike price and the current stock price are \$95.

the payoff of this strategy when the option expires 1 year from now. (2) What is the r that makes the strategy a "90/10" one, meaning putting 90% in the money market today and earning just enough to exercise the option at expiration? (This strategy is called the **90/10 strategy**.)

7.4.2 Spread

A **spread** consists of options of the same type and on the same underlying asset but with different strike prices or expiration dates. They are of great interest to options market makers. We use X_L, X_M, and X_H to denote the strike prices with $X_L < X_M < X_H$.

A **bull call spread** consists of a long X_L call and a short X_H call with the same expiration date. The initial investment is $C_L - C_H$. The maximum profit is $(X_H - X_L) - (C_L - C_H)$, and the maximum loss is $C_H - C_L$. The risk posture is defensive. See Fig. 7.7 for illustration. This spread is also known as **price spread**, **money spread**, or **vertical spread** (vertical, because it involves options on different rows

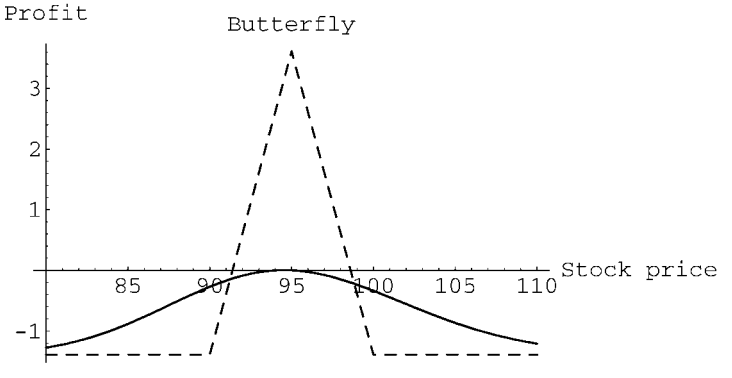

Figure 7.8: Profit of butterfly. Plotted is the profit diagram of a butterfly at expiration (dashed line) and at 1 month before expiration when it is initially set up (solid curve). The strike prices are \$90, \$95, and \$100, and the current stock price is \$95.

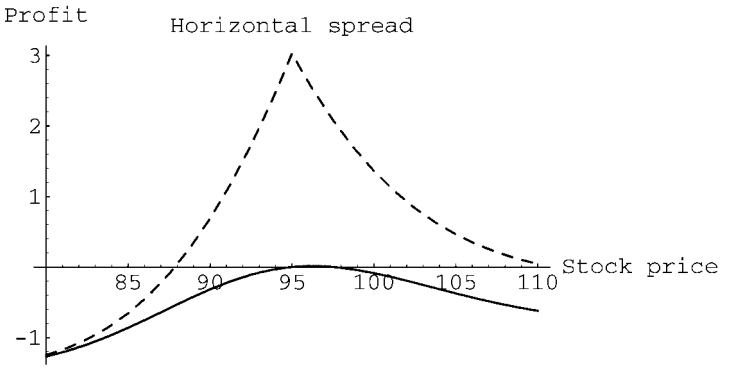

Figure 7.9: Profit of horizontal spread. Plotted is the profit diagram of a horizontal spread at expiration of the near call (dashed curve) and at the time when it is initially set up (solid curve). Both the strike price and the current stock price are \$95. There is one month to the first expiration date and two months to the second expiration date.

of the same vertical column as is obvious from Fig. 7.4). Writing an X_H put and buying an X_L put with identical expiration dates will create the so-called **bull put spread**. A **bear spread** amounts to selling a bull spread. It profits from declining stock prices.

EXAMPLE 7.4.1 An investor bought a call. Afterwards, the market moved in her favor, and she was able to write a call for the same premium but at a higher strike price. She ended up with a bull spread and a terminal payoff that could never be negative.

Three calls or three puts with different strike prices and the same expiration date create a **butterfly spread**. Specifically, the spread is long one X_L call, long one X_H call, and short two X_M calls. The first two calls form the **wings**. See Fig. 7.8 for illustration. A butterfly spread pays off a positive amount at expiration only if the asset price falls between X_L and X_H. A butterfly spread with a small $X_H - X_L$ thus approximates a **state contingent claim**, which pays \$1 only when a particular price results [346].[2]

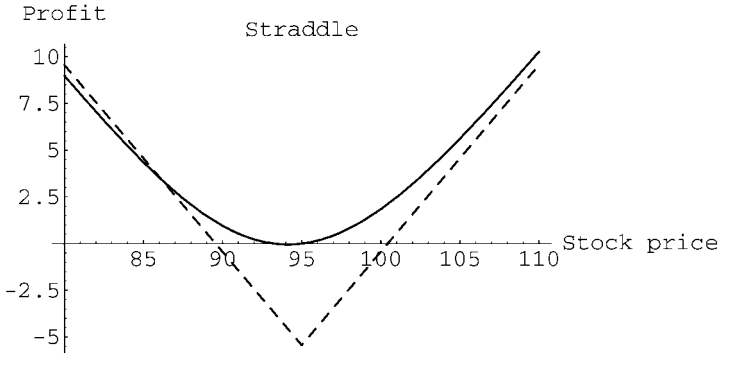

Figure 7.10: Profit of straddle. Plotted is the profit diagram of a straddle at expiration (dashed line) and at 1 month before expiration when it is initially set up (solid curve). The strike price and the current stock price are both \$95.

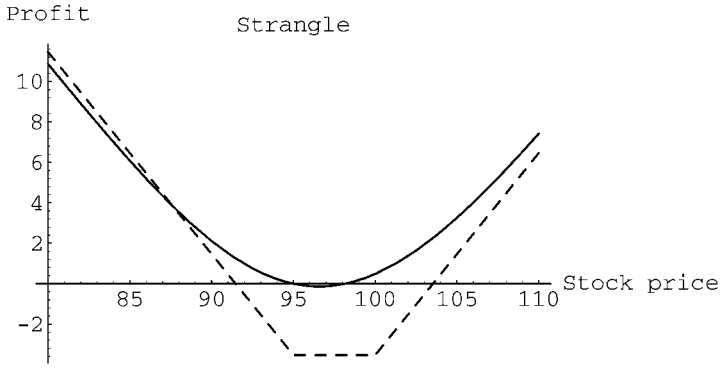

Figure 7.11: Profit of strangle. Plotted is the profit diagram of a strangle at expiration (dashed line) and at 1 month before expiration when it is set up (solid curve). Here the strike prices are \$95 (for the put) and \$100 (for the call), and the current stock price is \$95.

A **horizontal spread** (also called **time spread** or **calendar spread**) involves two options with the same strike price but different expiration dates. A typical horizontal spread consists of a long call with a far expiration date and a short call with a near expiration date. Its profit pattern arises from the difference in the rate of time decay between options expiring at different dates. See Fig. 7.9 for illustration. A **diagonal spread** involves two options with different strike prices and different expiration dates.

➤ **Exercise 7.4.5** A state contingent claim has a payoff function f such that $f(x) = 0$ for all $x \neq X$ and $\int_{-\infty}^{\infty} f(x)\,dx = 1$. Mathematically, f is called the **Dirac delta function**. Argue that the value of a state contingent claim equals $\partial^2 C/\partial X^2$.

7.4.3 Combination

A **combination** consists of options of different types on the same underlying asset, and they are either all bought or all written. A **straddle** is created by a long call and a long put with the same strike price and expiration date. A straddle is neutral on the direction of price movements and has limited risk. Because it profits from high volatility, a person who buys a straddle is said to be **long volatility** [646]. See Fig. 7.10 for illustration. In contrast, selling a straddle benefits from low volatility with a maximum profit of $C + P$. A **strangle** is identical to a straddle except that the call's strike price is higher than the put's. Figure 7.11 illustrates the profit pattern of a strangle.

A **strip** consists of a long call and two long puts with the same strike price and expiration date. A **strap** consists of a long put and two long calls with the same strike price and expiration date. Their profit patterns are very much like that of a straddle except that they are not symmetrical around the strike price. Hence, although strips and straps also bet on volatile price movements, one direction is deemed more likely than the other.

NOTES

1. Like the Holy Roman Empire, the terms American and European have nothing to do with geography.
2. State contingent claims are also called **Arrow securities** in recognition of Arrow's contribution [836].