The market in currency options

This article[1] is one of a series of background articles for the general reader explaining how different financial markets and other parts of the financial system work. It outlines the basic mechanics of currency options and the theory of options pricing and presents data on the growth of the market in currency options. It also describes some of the innovative variations on the basic currency option. As the article seeks to explain a complex area in a straightforward way, the descriptions of some of the concepts involved have been greatly simplified.

Introduction

In a world of floating exchange rates, companies and financial institutions engaging in transactions in foreign currencies are often exposed to the risk of loss (or reduced profit) as a result of unfavourable movements in exchange rates. This has created a demand for financial instruments which enable their buyers to insure (or hedge) against losses that may occur as a result of such movements. Currency forwards, futures, and options are examples of financial products that offer such protection.

The market in currency options has been one of the most rapidly growing and innovative sectors of the international financial market in recent years. Eighteen million currency options contracts were traded on the floors of exchanges around the world in 1988. Market estimates suggest that the over-the-counter (OTC) market in these instruments may be even larger. The growth of the market in currency options in recent years has meant that they have become an integral part of the global market in foreign currencies, complementing the longer-established spot and forward markets.

The mechanics of currency options[2]

An option may be defined as a contract offering the purchaser the *right* but not the *obligation* to buy ('a call option') or sell ('a put option') a given quantity of a specified financial instrument or physical commodity at a pre-determined price ('the strike price') either before or at a fixed future date. The financial instrument (or physical commodity) concerned is known as the *underlying instrument* of the option. The seller (or writer) of the option sells it to the buyer (or holder) and, in return, receives the option premium. The option contract extends (or is 'alive') until a set expiration or maturity date. An option that can be exercised at any time between the date of writing and the expiration date is known as an *American option*. An option that can only be exercised at maturity is known as a *European option*. When the market price of the underlying instrument is below the strike price, a call option is said to be 'out of the money' and a put option is said to be 'in the money'. Conversely, when the market price is above the strike price, a call is 'in the money', and a put is 'out of the money'.

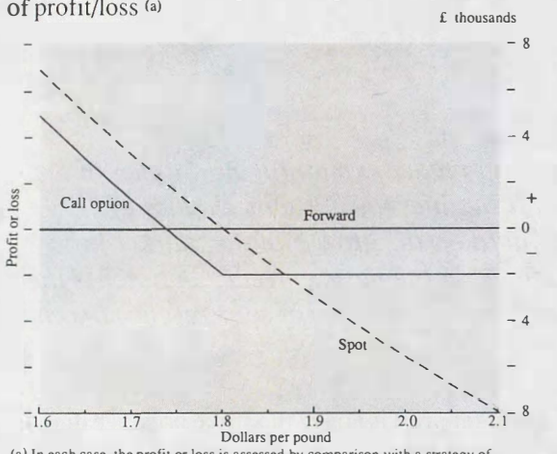
Currency options are used by corporate treasurers and international fund managers to hedge against the risks that result from movements in exchange rates. The use of a European currency option for this purpose can be illustrated by considering the case of a UK-based corporation (or institutional investor) that expects to receive US$100,000 of export (or investment) income in three months' time. Since the company will wish to convert into sterling, it will have an exposure to the spot dollar/sterling rate in three months' time. As this rate cannot be known in advance, the company faces *uncertainty* as to the sterling value of its future dollar earnings. Such uncertainty makes the company's financial planning difficult. The uncertainty could be eliminated by selling dollars and buying sterling in the forward market. If the effect of the prevailing spot rate and forward discount/premium is to produce a three-month forward rate of $1.80 and the company decides to hedge with a forward contract at the quoted rate, it knows with *certainty* that it will receive £55,555 ($100,000/$1.80) in three months' time.

If the company does not sell forward in this manner it runs the risk of making losses or profits. If the spot rate in three months' time were $1.90, converting at the spot rate would result in receipts of £52,632. This would represent a loss of £2,924 when compared with the forward hedge described above. On the other hand, if the spot rate in three months' time were $1.60, converting at the spot rate would result in a profit of £6,944 relative to the forward position.

The purchaser/holder of a *currency option* can use it as a hedging method which (like the forward) puts a limit on the losses that dealing at the spot rate could generate but (unlike a forward) does not eliminate all of the potential profits, because the holder of the option, unlike a buyer of a future or forward, is not obliged to complete the transaction at the predetermined exchange rate. The UK company could hedge its exposure by buying a *European*

(1) Written by Sanjiv Shah in the Bank's International Division.
(2) Many of the points made in this section are equally applicable to options on any other type of financial instrument or physical commodity.

Chart 1
Call option and unhedged strategies: comparison of profit/loss (a)



(a) In each case, the profit or loss is assessed by comparison with a strategy of hedging through the forward market.

call (to buy sterling) option at a strike price of $1.80. The profit/loss profile from using this option strategy as opposed to covering in the currency forward market is shown in Chart 1, where the option premium is assumed to be £2,000.

If the spot value of sterling in three months' time is lower than the strike price, say $1.60, (ie the call is 'out of the money'), the company will not exercise the option (which will simply expire) and will, instead, convert its dollars at the more favourable spot rate. In this case, the company will have made a profit as compared with dealing at the forward rate. On the other hand, if the spot value of sterling in three months' time is higher than the strike price of the option (eg $2.00), the option, which is 'in the money', will be exercised and the company's only loss compared with the forward position will be the £2,000 premium paid for the option. Chart 1 also shows the company's profit and loss if it elects not to hedge at all, but simply to convert at the spot rate in three months' time.

The return from the (unhedged) spot position is higher than the option position if the dollar is stronger than the strike price or if it is only slightly weaker. However, as exchange rates become more unfavourable, ie if the dollar is significantly weaker than the strike price, the loss suffered by the option holder remains limited, while the loss incurred by unhedged entities having to use the spot market is not. This demonstrates the main feature of options: they allow the holder, for a fee, to put a 'floor' to the possible loss but allow him the opportunity to benefit from a favourable movement in the price of the underlying instrument.

The evolution of the options markets

Although the trading of options on physical commodities has a long history, there was relatively little activity in *financial options* before the 1970s. Until the early 1970s, financial options were traded in *over-the-counter (OTC) markets*—a general term for a market in which trades are arranged bilaterally, usually by telephone, in contrast to *exchange-traded markets* where trading is usually done on the floor of an organised exchange. Table A summarises the main differences between the two types of market.

Table A
OTC and exchange-traded markets: main differences

	OTC	Exchange
Terms of contracts	Negotiable. (Customised for specific customer requirements.)	Standardised. Terms such as maturities, expiry dates and nominal amounts are fixed
Trading techniques	By telephone (with 'indicative' prices quoted on screens).	Open-outcry on exchange floor. (Some of the new exchanges have introduced automated trading on screens.)
Credit risk	Borne by transactors.	Borne by clearing house to whom transactors make margin payments. (Some exchanges do not have a clearing house and credit risk is borne by transactors.)
Major participants	Commercial and investment banks, (as buyers and sellers), corporations and fund managers (mainly as buyers).	Same as the OTC market plus specialised broking firms and individual traders (as principals).
Trading hours	Follows the cash market; eg the currency option market trades simultaneously with foreign exchange market.	Limited to the normal working day of the particular exchange. Recently some exchanges have extended trading hours while others have proposed screen-trading of their contracts outside their normal trading hours.

Exchange-traded options

The opening of the Chicago Board Options Exchange (CBOE) in 1973 marked the establishment of the first registered securities exchange for the trading of financial options. The CBOE began with a small number of option contracts on individual company stocks. This was quickly followed by the establishment of stock option contracts on a number of other stock exchanges in the United States. In the early 1980s, the market in financial options broadened considerably as exchange-traded option contracts on many other financial instruments (such as debt instruments, financial futures and foreign currencies) were established. For example, in December 1982, the Philadelphia Stock Exchange (PHLX) introduced a sterling/dollar currency option contract, and in early 1983 four option contracts for other currencies were established there. Exchanges for the trading of financial derivatives (including currency options) were also established in financial centres outside the United States. The London International Financial Futures Exchange (LIFFE) was opened in London in September 1982 for the trading of a number of financial futures and option contracts: it introduced currency option contracts in 1985. Financial option contracts were also introduced on several existing stock and commodity exchanges in a number of countries. This expansion is reflected in a rapid growth of the volume of currency option contracts traded, as shown in Table B. The number of such contracts traded on

Table B
Exchange-traded currency option contracts: total annual volume

Thousands of contracts: *the numbers of different currency option contracts listed on each exchange at the end of the year are shown in italics.*

Exchange	1983		1984		1985		1986		1987		1988	
Philadelphia Stock Exchange (PHLX)	194	*5*	1,104	*6*	3,747	*6*	7,875	*7*	10,761	*8*	9,994	*8*
Chicago Mercantile Exchange (CME)(a)	—		60	*1*	2,162	*3*	4,256	*5*	7,048	*5*	7,613	*6*
European Options Exchange (EOE)	89	*1*	338	*3*	509	*5*	518	*3*	692	*2*	503	*2*
Chicago Board Options Exchange (CBOE)	—		—		129	*6*	458	*6*	237(b)		—	
London International Financial Futures Exchange (LIFFE)	—		—		139	*1*	113	*2*	18	*2*	11	*2*
London Traded Options Market (LTOM)	—		—		89	*2*	44	*2*	22	*2*	7	*2*
Montreal Exchange	37	*1*	75	*3*	54	*4*	3	*1*	1	*1*	—	
New York Cotton Exchange (NYCE)	—		—		—		1	*1*	15	*1*	4	*1*
Sydney Futures Exchange (SFE)	—		—		1	*1*	2	*1*	—	*1*	—	*1*
Singapore International Monetary Exchange (SIMEX)	—		—		—		—		3	*2*	81	*2*
Total	**320**	*7*	**1,577**	*13*	**6,929**	*29*	**13,270**	*26*	**18,797**	*22*	**18,213**	*21*

Sources: Dale, Leslie and Wyatt: *Futures and Options: Winners and Losers*, Financial Times Business Information, 1988; Futures Industry Association Newsletters; Individual Exchanges.

(a) CME contracts are options on the CME's currency futures.

(b) CBOE delisted its foreign currency options contracts in August 1987 and transferred them to the Phipadelphia Stock Exchange.

exchanges grew very rapidly in the years 1982–87, though the growth of the market (at least in volume terms) appears to have been checked in 1988. In the United States, trading on the two main exchanges, the PHLX and the Chicago Mercantile Exchange (CME) in Chicago, has grown particularly rapidly. In the Far East, there are two exchanges where currency options are traded: the Sydney Futures Exchange (SFE) and the Singapore International Monetary Exchange (SIMEX). In Europe, the main exchanges for the trading of currency options are the Amsterdam-based European Options Exchange (EOE), LIFFE and the London Traded Options Market (LTOM).

As in other international financial markets, the US dollar is the central currency in exchange-traded currency options. Almost all the contracts currently traded involve buying or selling a non-dollar currency against the dollar. The currencies whose contracts are traded most are sterling, the deutschemark, the yen and the Swiss franc (see Table C). Other currencies whose contracts are traded include the French franc, the Australian dollar and the ECU. The currencies listed on a particular exchange may reflect the nature of the underlying demand in the market and the time zone in which the exchange is located. SIMEX, whose business day overlaps substantially with that of Japan, has a successful yen/dollar contract. Successful guilder/dollar and sterling/dollar contracts are traded on the EOE and the two London-based exchanges respectively. Most exchange-traded contracts have original maturities in the three-month to one-year range. In general the nominal principal amounts of exchange-traded contracts are relatively small. For example the sterling/dollar contracts on the LTOM have a principal amount of £12,500.

Table C
Value of exchange-traded contracts by bilateral exchange rate against US dollar

US $ millions

	Yen	Deutsche-mark	Swiss franc	Sterling	Canadian dollar	Other	Total
1982	—	—	—	68	—	50	**118**
1983	906	1,133	1,300	2,433	767	896	**7,435**
1984	6,413	40,153	8,972	12,290	3,504	2,792	**74,124**
1985	15,384	85,747	33,890	39,889	5,782	4,775	**185,467**
1986	134,041	198,159	138,037	39,363	8,126	4,787	**522,513**
1987	301,211	365,834	143,289	62,678	11,485	8,021	**892,518**
1988	435,707	316,762	144,220	72,760	39,229	10,453	**1,019,131**

Source: Bank of England estimates based on data from Table B.

The OTC currency options market

The OTC market in currency options has developed strongly in the major financial centres, especially London and New York. The OTC market in London developed in the late 1970s as banks began to write options for three to four months' maturity to meet customer risk management needs. There was only a modest volume of activity in the period up to 1983. Since then, the market in London has developed strongly as many domestic and foreign commercial and investment banks have expanded their options operations. Part of the activity in the OTC market is accounted for by banks writing currency options for companies and institutional investors who are seeking to hedge against foreign exchange risk. Alongside this 'retail' market, a 'wholesale' interbank market has developed rapidly. The latter was boosted by the participation of many foreign commercial and investment banks, a development which accelerated following the publication in August 1985 of the British Bankers' Association's standardised terms and conditions for options trading in London (the 'LICOM' terms). The wholesale market is used by banks to hedge or 'insure' options that they have written for customers in the retail market or to trade options for their own accounts. Some of the new entrants to the OTC market specialise in own-account trading and write very few currency options for customers. As a result of the growth in the number of banks willing to make markets in currency options, the OTC market has become more competitive and its liquidity has improved. The growing maturity of the market is reflected in an increase in the size of individual transactions. The development of the market is also indicated by an increase both in the range of currencies in which options are written and in the maturities for which banks are willing to write and trade currency options.

Definitive data on the size of the OTC market are not available. A 1986 study[1] reported that the two largest markets, in New York and in London, were roughly equivalent in turnover and outstanding amounts, with outstanding foreign exchange options in each market amounting at that time to around $10 billion. Estimates by market participants suggest that activity, especially in

(1) *Recent innovations in international banking*, BIS, 1986, page 72.

London and Tokyo, has grown particularly strongly since then. Although reliable statistical evidence is not available, there seems little doubt that the OTC market for foreign currency options has grown at least as rapidly as the exchange-traded markets. Both sectors have shown considerable growth both in overall volumes and in the types of contracts traded.

The growth of options trading

The rapid growth in trading volumes of financial instruments such as currency options over the past decade can be attributed to a number of factors. First, greater volatility in interest rates and exchange rates increased the demand for hedging instruments such as options, as well as forwards and futures, which offer protection against the market risks generated by such volatility. Second, the growth in cross-border capital flows in recent years (which reflects deregulation in domestic capital markets and the removal of constraints on overseas investment in some countries) has increased the absolute volume of funds that are exposed to foreign exchange risks. Third, important advances in option pricing theory that had occurred in the 1970s, combined with improvements in computer technology, fostered the development of sophisticated models for the pricing of options. In addition, improvements in technology increased the ability of financial intermediaries to monitor and manage the risks arising from the writing and the trading of options. This is particularly important for institutions which are active traders of options in the interbank market and which may occasionally take large unhedged option trading positions. The increased liquidity of the OTC and exchange-traded markets, a result of higher trading volumes, both increased the ability of financial institutions to hedge positions generated by writing options in the OTC market and reduced the costs of doing so.

Exchange-traded versus OTC option markets

Exchange-traded options provide traders in the interbank market with a market in which to hedge option positions and exploit any price anomalies between the OTC and exchange-based options markets. However, the standardised terms of exchange-traded contracts mean that they cannot meet the requirements of buyers on the OTC markets exactly and can usually only provide a partial or imperfect hedge. In contrast, the fact that the terms of transactions on OTC contracts can be arranged to suit the potential buyers' specific requirements means that much more exact hedges are possible in the OTC market.

The increase in competitiveness and liquidity in the OTC market in recent years has greatly increased its importance for options trading relative to the exchange-traded market. The slowdown in the rate of growth in the volume of options traded on exchanges (see Tables B and C) may be evidence of the increased relative attractiveness of the OTC market. In particular, the modest performance of the London exchanges in currency options (other financial contracts such as equity options or interest rate futures have been much more successful on the London exchanges) is probably due to the size and liquidity of its OTC market in currency options. Some market makers in London concentrate their activity in the OTC market and only conduct significant business on the exchanges on the rare occasions when there are large price anomalies between the two markets or when general concern about the credit standing of financial institutions leads to a tightening of credit lines in the interbank market. The growth of the OTC market in currency options has been aided by a number of advantages it has been perceived to have over the exchange-traded market. First, it is effectively a twenty-four hour market, as banks pass their option trading books from a financial centre in one time zone to a centre in another zone as the day progresses. A company that chooses to wait until an exchange in its own time zone is open before it hedges its exposure runs the risk of losses resulting from price movements in markets in another time zone. Second, the size of the contracts on OTC markets and the range of currencies on which options are written is generally much larger than on the exchanges. Therefore, many end-users of options find the OTC market is more suitable for their needs.

The exchanges have responded to the challenge from the OTC market in a number of ways. First they have attempted to extend their trading hours. For example the PHLX now has an evening trading session and an early morning trading session. These are intended to meet more effectively customer demand from the Far East and Europe respectively. The CME has set up a scheme which will allow its contracts (and those of other exchanges that join the system) to be traded electronically outside normal trading hours in a system called Globex (Global Exchange). Some exchanges have also increased the nominal principal amounts of some of their contracts. For example, the PHLX has increased the size of its sterling dollar contract from £12,500 to £31,500 and has seen strong demand for the larger contract.[1] In addition to these measures, the exchanges have also emphasised the advantages that they have over the OTC market. As transactions occur on the trading floor, price transparency is greater than in the OTC market. It is possible for transactors to buy and sell exchange-traded contracts without revealing their identity to the counterparty. This is not usually the case in the OTC market where potential transactors have to evaluate the credit standing of potential counterparties. The presence of the clearing house and a system of margining means that the credit risk of trading on the exchanges is greatly reduced.

The pricing of options

Although the study of the determination of option prices has a long history, a satisfactory theory of the valuation of

(1) The exchanges may be cautious about increasing the sizes of contracts because larger lots might deter individual traders (locals) who provide valuable liquidity on some exchanges.

Variants on the basic currency option product

Banks have developed a number of variants on the basic currency option, partly out of a desire to reduce or eliminate the 'up-front' premium in order to meet the specific requirements of end-users of options. These variants have a number of different names as individual financial institutions have, as part of their marketing strategies, given 'proprietary' names to similar products. Most of these variants are of two generic types: hidden premium options or reduced premium options.

Hidden premium options provide users with an option-like facility which gives them the 'option' to *break out* of a forward position and transact in the spot market. No up-front premium is payable, and the costs of the transaction are incorporated into the fixed rate agreed for the forward (which is at a discount to the 'true' forward rate).

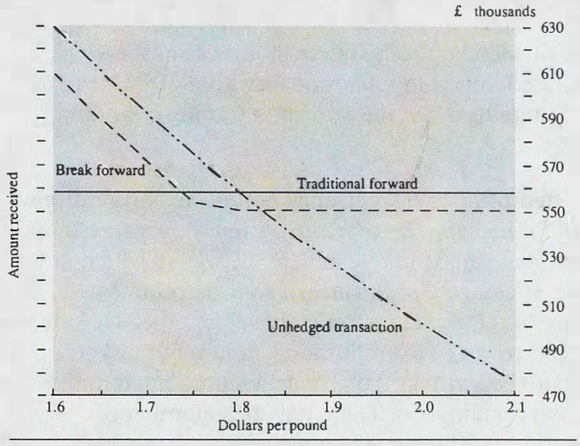
Reduced premium options give the buyer a wider degree of choice of the level of risk insurance and, therefore, of the 'up front' premium. They involve two currency options, one bought by the customer from a financial institution and the other, with a different strike price, written by the customer usually to the same financial institution. The two transactions are simultaneous and can be made to fit a customer's particular risk profile.

A hidden premium option: a break forward

A UK exporter is expecting to receive $1 million in three months, the spot rate is assumed to be $1.79 and the three-month forward rate is $1.80. A pure forward would result in receipts of £555,555. Alternatively, the exporter can enter into a hidden premium option contract for three months to sell dollars and buy sterling. The exporter is assumed to set the forward rate (FR) for this transaction at $1.854 (a discount of 3% to the true forward rate). The bank writing the option is assumed to set the price at which the buyer can *break out* of the forward (BF) at $1.76. The BF is, in effect, the strike price of the transaction. If the spot rate in three months' time is above $1.76, the exporter is obliged to convert at the agreed forward rate of $1.854 and in this case would receive £539,374. On the other hand, if the spot rate is below $1.76, the break facility will come into operation. This involves the exporter selling $1 million at the forward rate (FR = $1.854) and then buying dollars at the break rate (BR = $1.76). Then the exporter is free to transact at the favourable prevailing spot rate. Therefore if the spot rate were to fall to $1.74, the exporter would pay £568,182 ($1 million/1.76) for buying the dollars and then receive £539,374 for selling the dollars at the FR($1 million/1.854) before finally selling the dollars in the spot market to receive £574,713. The resulting net receipts are £545,905.

The hidden premium option is compared with both the traditional forward and the spot market transaction in Chart A. The payment profile may be looked at from the point of view of the intermediary who is willing to write either a three-month forward or a break forward. If the spot rate is above $1.76, the writer has to pay fewer pounds in exchange for the $1 million under the break forward than he does under the traditional forward. The difference is represented by the vertical distance between the traditional forward and the break forward line in Chart A. This is the additional cost incurred by the exporter for using the break forward rather than the traditional forward, just as the option premium is the cost of using an option rather than a forward. The only difference is that in an option the premium is paid up front, while in the case of the break forward the cost is embedded in the pay-off profile for a range of possible outcomes of the price of the underlying instrument.

Chart A:A hidden premium option: the break forward

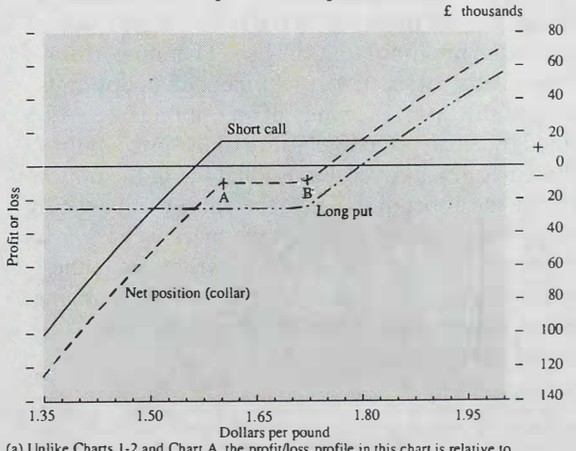


A reduced premium option: the collar

The UK exporter buys an 'in the money' European put option (to sell dollar proceeds from exports) with a strike price of $1.72 at a time when the spot rate is $1.80. In addition the exporter writes an 'out of the money' call option (which gives the bank the option to buy dollars) with a strike price of, say, $1.60, for which a premium is received. Therefore, the exporters' net cost is the premium paid for the put option bought minus the premium received for the call option that has been written. The resulting pay-off profiles are shown in Chart B.

The strike price on the call option that has been written by the exporter can be adjusted in order to achieve the (net) premium that the exporter wishes to pay. Although the premium on a collar is lower than that on a conventional option with similar terms, this is only achieved because the end-user bears greater risk with a collar than he does with a plain option. The latter offers an absolute limit on the opportunity loss that the holder can suffer while in the former case this protection is only available for a 'collar' or range of spot rates. If the put option that the exporter has bought becomes more and more 'out of the money', the exporter will sustain significant opportunity losses. The width of the 'collar' (shown as the distance A–B in Chart B) and therefore the degree of protection that this type of transaction gives, is determined by the strike price of the call option written by the exporter or, what amounts to the same thing, the premium that the exporter wishes to receive for the option that he has written.

Chart B: A reduced premium option: the collar[a]



(a) Unlike Charts 1-2 and Chart A, the profit/loss profile in this chart is relative to transactions in the spot market.

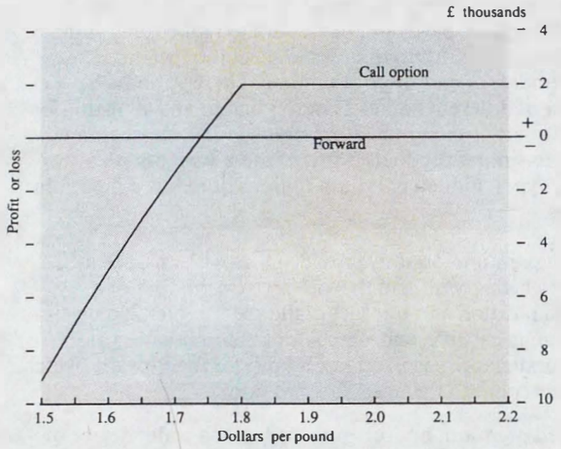
options was not developed until the early 1970s. In 1973, the Black-Scholes (B-S) model for the valuation of European options on equities was published[1] (see the appendix). Since then, it has been modified to price other types of financial options. These modifications have been incorporated into computer models whose widespread use has undoubtedly aided the growth of trading in options markets.

Banks attempting to sell currency options to corporations as a tool for hedging their foreign currency exposures have however been forced to re-evaluate the way in which the premium is charged, in the face of some corporate resistance to the greater use of currency options. Despite the strong growth in overall trading volumes, market participants report that the proportion accounted for by companies remains low. There may be a number of reasons for this reluctance to use options. Companies may, after comparing the relative costs and benefits of the two instruments, conclude that currency forwards are a more cost-effective hedging tool. Some corporations may not fully understand the mechanics of currency options and may prefer to use currency forwards, the traditional hedging instrument, with which they are likely to be more familiar. However, the main reason for corporate resistance to currency options seems to be the fact that buyers have to pay the premium 'up-front'—ie at the beginning of the period which the currency option is going to cover. Banks have responded by redesigning option transactions in order to reduce or eliminate the need for the premium to be paid at the initiation of the contract. The buyer of the option still has to pay for the protection that the option offers. However, this is done through a level of pricing which effectively discounts the premium rather than through the payment of an explicit 'up-front' premium. (See the note on page 239.)

The risks from options and hedging strategies

The distribution of market risk between the buyer and seller of an option is asymmetric. As shown above, the holder of an option faces limited potential opportunity loss but unlimited potential opportunity profit. The writer (or seller) of the sterling call option has the opposite profit and loss profile, as shown in Chart 2. The writer of the option bears the risk of incurring the potentially large loss and receives the premium for doing so. Therefore, from the option seller's perspective, the pricing of an option is the pricing of this risk. The value of an option is determined by the expected volatility of the price of the underlying instrument over the residual life of the option contract (see the appendix). Thus, the value of an existing option may change simply because the market changes its expectation of future volatility. Option writers have the problem of managing the risk arising from both changing prices of the underlying instrument and changes in expected volatility.

Chart 2
Call option :writer's profit and loss profile[a]



(a) In comparision with a forward position.

The aim of risk management is to hedge against the potential losses on the option position that may be generated as a result of changes in the prices of the underlying instrument. The degree of protection sought would depend on the option writer's attitude to risk. A strongly risk-averse writer would want a hedge in which any loss (gain) on the option position is exactly offset by a gain (loss) on the hedge.[2] A more risk-neutral writer would leave a part of the option position unhedged.

An option position may be hedged either with a cash hedge or with an option hedge. A *cash hedge* involves being long or short (depending on whether a call or a put has been written) on the option's underlying instrument.[3] For the writer of an American call option to buy sterling, constructing a cash hedge implies having a long position in sterling.[4] Once a hedge is in place, any losses on the option position as a result of an adverse movement in the price of the underlying instrument will be offset by a gain on the hedge. Continuing the earlier example of a sterling call option, if sterling appreciates against the dollar to $2.20 the option will move 'into the money' and will be exercised by the holder. As a result, the writer will incur a loss relative to the spot position. However, the appreciation of sterling will result in a gain on the long sterling position.

An *option hedge* involves an offsetting transaction in the options market. For example a risk-averse writer (or seller) of a sterling call option could hedge it by buying a sterling call option with identical terms. Since the prices of the two matching options should roughly be matching, any profits on such trading will on average be limited to the market's bid-offer trading spreads. A market-maker who is an active buyer and seller of options would find that many of the positions would be self-hedging. Such 'pooled insurance', which would arise in large trading books which had a balanced dispersion of exercise prices, maturities and puts and calls, means that net exposures

(1) Fisher Black and Myron Scholes, 'The price of options and corporate liabilities' *Journal of Political Economy*, May-June 1973, pages 637–59.
(2) This would be a 'delta-neutral' hedge. See *Recent innovations in international banking*, BIS, 1986, pages 77–80.
(3) The concept of the underlying instrument for a currency option needs to be elaborated. The underlying instrument is that currency which the holder of the option will have after the option is exercised. In the case of sterling/dollar options, the underlying instrument for a sterling call is sterling while for a sterling put option the dollar is the underlying instrument.
(4) For hedging European options, the hedge could be a long forward (or futures) position instead of the long cash position.

may be small relative to the volume of options traded. The degree of risk pooling should not, however, be exaggerated. Customer demand is often clustered around particular prices and maturities. This makes it difficult for banks to attain a balanced trading book and, consequently, limits the amount of risk pooling possible.

On credit risk, the writer of the option is exposed to the buyer for the amount of the premium. After exercise, there are several possible settlement risks but all involve obligations to perform by both parties. With currency options, both parties are obliged to deliver one of the two currencies involved, whether the option is a put or a call. The settlement risk changes substantially if, as is the case with some OTC currency options, contracts are cash settled. In this case, only the party receiving the payment, the option holder, will be exposed to settlement risk.

Prospects for the options market

The volume of trading in currency options has grown rapidly in the 1980s. Currency options satisfy a demand for a particular type of hedge against the potential foreign exchange risk to which entities engaged in foreign currency transactions are exposed. The need for such protection, and, therefore, the demand for currency options, are likely to endure for as long as exchange rates are subject to uncertainty.

Appendix

The pricing of options

The derivation of the Black-Scholes (B-S) pricing model involves some complex mathematics[1] and only an intuitive explanation is given here.[2] However, its basic principles can be stated in a relatively simple way. The correct value of an option is a function of five variables. These are:

(i) The spot price of the underlying instrument (S);

(ii) The strike price of the option (K);

(iii) The level of interest rates (R);

(iv) The time to expiry of an option (T); and

(v) The expected volatility of the spot price of the underlying instrument over the life of the option (V).

The correct price for an option may be defined as follows:

$$\text{Price} = \text{Intrinsic value } (IV) + \text{Time value } (TV) \qquad (1)$$
$$\text{where } IV \text{ and } TV \geqslant 0$$

Intrinsic value (IV) is the opportunity profit that the holder of an option would make if the option were exercised immediately. IV is a positive function of the difference between the strike price (K) and the spot price (S).

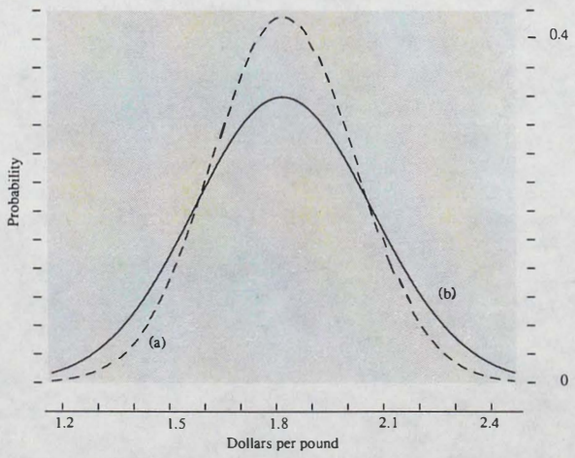
$$IV = f(K-S) = \text{Nominal value of option} \times (K-S) \qquad (2)$$

This result can be illustrated by using the example of a $100,000 sterling call option (to buy sterling and sell dollars) with a strike price of $1.80. If the current spot rate is $2.00 (the option is 'in the money') the intrinsic value of the option is given simply by the difference between K and S ($2.00–$1.80) multiplied by the nominal value of the option ($100,000)—ie $20,000. If the option is 'out of the money' (eg if the spot rate is $1.60), it is not profitable to exercise the option and IV is zero. However, the option is still likely to have a positive worth because of its time value.

Time value (TV) may be defined as the opportunity profit (over and above the intrinsic value) that can be expected to be made over the residual life of the option. Time value is negatively related to the rate of interest (R) and positively related to the volatility of the price of the underlying instrument (V) and the time to expiration (T).

As TV is the present value of a *future amount*, a change in R implies a change in the discount rate and, therefore, a change in TV. For a given discount rate, time value will be a positive function of the future profit that the option is expected to make over its residual life. Other things being equal, the longer the option's period to expiration (T), the higher the probability that a given level of profit will be made. Similarly, the greater the expected volatility of the price of an underlying instrument, the higher the probability that a given level of profit will be achieved. It would therefore be expected that the time value, and consequently the price of an option, would be a positive function of T and V.

The value of the first four of the variables that determine the price of an option can readily be established. Any disagreement about the value of an option must, therefore, be due to different expectations about the value of the fifth variable—the future volatility of the spot price of the underlying instrument. A trader who wishes to price an option has to forecast future volatility. Two traders may have different forecasts of future volatility such that their probability distributions for the price of an underlying instrument are those shown below:



Distributions (a) and (b) have the same mean but (b) has a greater variance than (a). The trader who expects price distribution (b) expects greater volatility than the one who expects price distribution (a) and therefore would value the option more highly. If the actual volatility of the underlying asset price were to be closer to that in distribution (a), then the trader who expects distribution (b) would find that he has overpriced the option.[3]

(1) See *Recent innovations in international banking*, BIS, 1986, pages 103–6.
(2) For a more rigorous treatment, see Cox and Rubinstein, *Options Markets*, Prentice Hall, 1985, Chapter 5.
(3) The B-S model assumes that the underlying asset prices are normally distributed. Therefore it has been argued that it will mis-price options on underlying instruments which have a leptokurtic (fat-tailed) or discontinuous price distribution.