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Foreign Currency Options: An Innovation in
the Foreign Exchange Market

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I. Introduction

In recent years interest in ways of managing foreign currency
exposure has increased considerably in light of large and, at times,
erractic changes in exchange rates. Forward markets for foreign ex-
change have, of course, been around for some time for most major cur-
rencies, and the ways in which these markets can be used to reduce
the risks from foreign currency exposure are well known. More
recently, an innovation has been introduced in the foreign exchange
market which adds a new dimension to the ways of protecting against
(hedging) exchange rate risks. This innovation is foreign currency
options. Basically, a foreign currency option is a contract that
provides the right (but not the obligation) to purchase or sell a pre-
determined amount of foreign currency at a specified exchange rate on
or before the date of maturity of the contract.

This paper is intended to provide some background on and analysis
of foreign currency options. Although their use is not yet widespread,
foreign currency options appear to have a great deal of potential as
reflected in the establishment of organized trading in these options
on some exchanges in the United States, Europe, and Canada in the
last two and a half years, and in the rapid increase in trading
volume, especially over the last year or so. Some of these exchanges
have recently increased the number of currencies in which options
contracts are traded, while other exchanges have just started or are
planning to start foreign currency options trading for the first time.
Foreign currency options may ultimately become an important financial
instrument in facilitating international trade by reducing some of the
risks associated with a floating and flexible exchange rate system.

This paper is organized as follows. Section II lays out some of the terminology, mechanics and advantages associated with foreign currency options, including some numerical examples to help illustrate ways in which the options can work. Current market arrangements for buying and selling foreign currency options are discussed in Section III. Section IV elaborates on the uses of options as a tool for both hedging and for position-taking in the foreign exchange market. Section V is devoted to a discussion of the valuation of foreign currency options and the relationship between the options, forward, and spot markets for foreign exchange. A summary and some concluding remarks are presented in Section VI. While the question of how the foreign currency options market might in practice affect the volatility of other markets for foreign exchange is an important one, this paper is not designed to answer this question.

II. What is a Foreign Currency Option? – Some Terminology and Examples

There are two basic types of foreign currency options: put options and call options. A foreign currency call option is a contract that provides the contract holder with the right to purchase (or "call away," and thus the name) an agreed amount of foreign currency at a specified price (exchange rate) on or before the maturity date of the contract. A put option, by contrast, provides the contract holder with the right to sell (or "put down") an agreed amount of foreign currency at a specified price on or before the maturity date. The specified price at which the foreign currency can be bought or sold is called the exercise or striking price. An option which can be exercised at any time up to the maturity date of the contract is known as an American option while an option that can be exercised only on the maturity date of the contract is known as a European option.

The buyer of an option contract pays to the seller of the contract a fee, called the premium. By paying the premium to the seller, the buyer of the contract (also called the contract holder) purchases the right to exchange foreign currency with the seller of the contract (also called the contract writer) at the striking price, either at any time up to the maturity date of the contract (American option) or only on the maturity date (European option). The buyer makes the decision of whether or not to exercise the option and since he may always decide to not exercise it his potential loss is limited to the premium. The seller of an option contract has exchange rate risk transferred to him, and sells the contract because in his view the premium received is sufficient compensation for his potential loss. The premium is the price of the option contract which moves to equilibrate supply and demand. For example, if a given premium did not provide sufficient compensation for the risk that sellers bear, there would be fewer sellers than buyers at that premium which would drive the premium up.

It is worth highlighting at the onset some of the main advantages of foreign currency options over forward or futures contracts as a means of averting exchange rate risk. One of the main attractions of foreign currency options is that they add more flexibility to risk management than is available with existing forward or futures foreign exchange markets. This flexibility stems from the fact that a foreign currency option literally entails an option and not an obligation. As a hedge, a foreign currency option limits the risk of an adverse change in the exchange rate by locking in the exchange rate given by the striking price. At the same time, the option gives its holder the ability to take advantage of any beneficial change in the exchange rate because the option need not be exercised. And no matter how the exchange rate moves, the holder of an option cannot lose more than the premium because there is not a binding obligation to exercise the option. By contrast, a forward or futures contract requires the holder of the contract to either acquire (or provide) the underlying currency at the set exchange rate or close out the contract. Thus, forward or futures contracts entail a binding obligation, irrespective of subsequent changes in exchange rates or in the circumstances of the contract holder. 1/

In the normal course of their international operations, economic entities also face exchange rate risks because of uncertainties about whether future foreign exchange transactions will take place. Foreign currency options are ideally suited to hedge this important kind of contingent risk exposure. For example, if a firm submits a bid to produce for export but is uncertain about whether the bid will be accepted, the contingent foreign currency receivable can be hedged with a put option. If the bid is not accepted, the option does not have to be exercised and the cost of hedging is limited to the size of the premium. 2/ The option, however, ensures that if the bid is accepted, the firm is protected against the risk of an adverse currency movement. If the firm had instead engaged in a forward contract to sell the potential foreign currency receipts and the bid was not accepted, the firm would have remained obligated to engage in a foreign currency transaction with its associated risk. In general, a foreign currency option is well suited to reducing exchange rate risk whenever an uncertain future cash flow in a foreign currency is involved.

1/ It should be noted that hedging foreign currency exposure through options (or forward or futures) contracts does not protect the holder from the ultimate economic effects of exchange rate changes once they occur. For example, a sustained home currency appreciation tends over time to reduce the demand for exports and raise the demand for imports; hedging individual transactions cannot protect the economic agents involved from these factors.

2/ In fact, there may even be an opportunity to profit if the premium has increased in value in the interval.

Two hypothetical numerical examples given below illustrate some of the mechanics of foreign currency options and highlight the advantages of hedging foreign exchange exposure with options. To keep the first example simple, the striking price and the spot exchange rate when the option is purchased are assumed to be the same, and the option can only be exercised on the maturity date of the contract (a European option). These conditions are relaxed in the second example.

1. Foreign currency call options: an example

Consider a hypothetical example of an American importer buying machinery from Germany. The importer knows the bill will come due in three months, when he must pay the German producer of the machinery DM 31.0 million, or $10 million, say, at the current spot exchange rate of DM 3.10 per U.S. dollar. To hedge against adverse movement in the exchange rate, the risk averting importer pays a $200,000 premium to buy a European call option that gives him the right to buy in three months DM 31.0 million at a striking price of DM 3.10 per U.S. dollar. Three of the possible outcomes are:

(i)   The DM appreciates from DM 3.10/$ to DM 3.00/$ after three months. Without the option, the American importer would have to pay $10.3 million, that is the DM 31.0 million owed to the German producer converted into dollars at the new spot rate of DM 3.00/$. By exercising the option, the American importer pays $10 million for the DM 31.0 million, i.e., $300,000 less. Hedging with the option cost $200,000 for the premium but saved $300,000 for a net gain of $100,000. 1/

(ii)   The DM depreciates from DM 3.10/$ to DM 3.20/$ after three months. The American importer pays $9.7 million (DM 31.0 million converted into dollars at the new spot rate of DM 3.20/$), or $300,000 less than the amount calculated on the basis of the initial spot rate. The option is not exercised because doing so would mean paying $10.0 million rather than $9.7 million for the needed Deutsche mark. Hedging with the options thus cost $200,000 for the premium, but because there was no obligation to exercise the option the importer was able to benefit from the $300,000 decline in the cost of the machinery as a result of the depreciation of the Deutsche mark.

(iii)   The DM remains unchanged at DM 3.10/$ after three months. The American importer is indifferent between exercising and not exercising the option, because in either case the machinery will cost him $10 million. There are neither gains or losses

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1/   Figures are rounded to the nearest $100,000. It may also be noted that for simplicity the interest foregone on the $200,000 premium does not appear in the calculations.

on account of exchange rate movement, but there is a cost of
$200,000 for the premium.

It is evident that the decision to exercise the option depends on
whether the foreign currency in question appreciates or depreciates. 1/
If the Deutsche mark appreciates in the above illustration, the call
option would be exercised because the option allows its holder to buy
the needed foreign currency at a more favorable exchange rate. The
option would not be exercised if the Deutsche mark depreciates because
it would then be cheaper to buy the currency at the new spot rate than
at the striking price. Unlike a forward or futures contract, the
option allows the importer to take advantage of the depreciating foreign
currency by simply not exercising the option, although he incurs the
"insurance" cost of the option's premium.

By using the foreign currency option to hedge, the importer cannot
lose more than the premium and only when the spot rate does not change
is the cost to the importer equal to the full amount of the premium.
Otherwise, some of the cost of the premium is offset either by gains
from executing the option (when the Deutsche mark appreciates in the
example) or by gains from an advantageous change in the spot exchange
rate (when the Deutsche mark depreciates in the example). In general,
options limit the downside risk from exchange rate movements while
allowing the contract holder to profit from any favorable exchange rate
changes.

Clearly the importer could have chosen not to cover his foreign
currency exposure at all. Had he done so and had the Deutsche mark
depreciated or remained unchanged, he would have been better off--in an
ex-post sense--since the option he might have purchased would not have
been exercised but would have cost him the premium. Had the Deutsche
mark appreciated substantially, however, he would have been far worse
off for not hedging. In either case, moreover, by not covering he
incurs an ex-ante exchange rate risk, something he presumably would
prefer to avoid if he is risk adverse.

Alternatively, the American importer could have hedged his for-
eign currency exposure by purchasing Deutsche mark in the forward
market. For example, suppose that the forward Deutsche mark exchange
rate against the U.S. dollar was DM 3.06 per dollar. Had the importer
covered forward, he would have locked in the cost of $10.1 million
(DM 31 million divided by DM 3.06/$) for the machinery, and subsequent
exchange rate movements would have no bearing on this cost. Subsequent
spot rate movements would, however, influence the cost when an option

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1/ The next example will illustrate that whether an option is exer-
cised depends in general on whether the foreign currency appreciates
or depreciates relative to the striking price. In this example, the
striking price and initial spot exchange rate were the same.

contract is used. So at different spot rates, either the option or the forward contract would prove to be more advantageous than the other. In the example, at an exchange rate of DM 3.10/$ or below (an appreciation of the Deutsche mark from its initial level), the cost would be $10.2 million with an option contract--higher than with outright forward cover. 1/ At an exchange rate of DM 3.14/$, the option and the forward contract would yield the same cost of $10.1 million (DM 31 million divided by DM 3.14/$ plus $200,000 for the premium). And for an exchange rate above DM 3.14/$ (a depreciation of the Deutsche mark from its initial level), the cost would be lower under an option contract. Whether using the forward market is a less costly alternative than the options market depends, ex-post, on the realized value of the spot exchange rate. 2/ In an ex-ante sense, whether an option is preferred to a forward contract as a means of hedging foreign currency exposure will likely depend on judgements as regards the various possible future exchange rate outcomes. The added flexibility associated with an option contract can make it a more preferred way of hedging, as it allows its holder to benefit from favorable exchange rate changes.

2. Foreign currency put options: an example

To illustrate some of the basic mechanics of a foreign currency put option, consider a U.S. firm that quotes a price of ¥ 2.5 billion to a Japanese company that is taking bids from various producers on some specialized products. The Japanese company will pick the winning bid and expect delivery within the next six months, but it may be almost anytime within the period. If the bid by the U.S. firm is accepted, the firm will receive ¥ 2.5 billion sometime within the period. At a current spot exchange rate of, say, ¥ 250 per U.S. dollar, the U.S. firm would receive $10 million, but of course the firm does not know what the spot exchange rate will be when it receives the ¥ 2.5 billion. If the bid is not accepted, there will be no foreign currency forthcoming. To hedge its contingent foreign currency receivable, the U.S. firm purchases a ¥ 2.5 billion American put option with a six-month maturity and a striking price of ¥ 240 per U.S. dollar. If the bid is accepted at any time within six months the firm has assured itself of receiving $10.42 million. The premium is $550,000 for the put option. Some of the possible outcomes are: 3/

1/ This can be seen from outcome (i) of the example above, noting that the cost of the machinery here is inclusive of the option's premium.

2/ It also depends on the striking price of the option contract and on the forward rate at the time that the transaction is undertaken. Here it may be interesting to note that in the options market it is the premium that is determined by market forces and there is generally a choice of different striking prices, while in the forward (or futures) markets the exchange rate is market determined.

3/ The outcomes given below also assume that the U.S. firm only makes the decision as to whether to exercise the option on the day payment is received. Of course, in the real world an option can present an ongoing decision process throughout the life of the option.

(i) The yen depreciates from its initial level of ¥ 250/$ to ¥ 260/$ by the time payment is received. Without the option, the firm could sell the ¥ 2.5 billion it receives for $9.62 million at the new spot rate. By exercising the option, the firm converts the ¥ 2.5 billion at the exercise price of ¥ 240/$ for $10.42 million. Hedging with the option cost $550,000 for the premium but the firm receives an additional $800,000 for a net gain of $250,000. 1/

(ii) The yen remains unchanged at ¥ 250/$. The firm would receive $10.0 million for the ¥ 2.5 billion if it converted the yen at the spot rate. But since the firm purchased the option, it can sell the ¥ 2.5 billion at ¥ 240/$, and receive $10.42 million instead so it exercises the option. Hedging with the option thus saves $420,000 less $550,000 for the premium for a net cost of $130,000.

(iii) The yen appreciates from its initial level of ¥ 250/$ to ¥ 230/$ by the time payment is received. The firm clearly benefits from the appreciation. The ¥ 2.5 billion is converted into dollars at the new spot rate of ¥ 230/$ and the resulting $10.87 billion represents a $870,000 gain from the yen's appreciation. The option would not be exercised because it is more advantageous to sell the yen at the new spot exchange rate rather than at the option's striking price of ¥ 240/$. Hedging with the option cost $550,000 for the premium, but because there was no obligation to exercise the option the firm was able to benefit from the $870,000 gain from a favorable exchange rate movement.

When the initial spot exchange rate and striking price differ, the decision to exercise the option is determined by whether the foreign currency in question appreciates or depreciates in relation to the striking price. If the yen depreciates from its initial level, the put option would be exercised since more dollars would be received by converting the ¥ 2.5 billion at the striking price of ¥ 240/$ than at the new depreciated spot rate. In addition, however, if the yen appreciates from its initial level without appreciating below the striking price of ¥ 240/$, more dollars would be received by exercising the option than by using the spot exchange rate. If the yen appreciates to a level which goes below ¥ 240/$, the option would not be exercised.

If the bid is not accepted, the cost to the U.S. producer will be limited to the premium, but the cost may in fact be less. If the yen has depreciated in relation to the striking price of ¥ 240/$, the option provides a riskless profit opportunity, since yen could be purchased

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1/ Figures are rounded to the nearest $10,000.

at the spot exchange rate and then sold at the striking price of ¥ 240/$. Suppose, for example, that the yen remained at its initial level of ¥ 250/$. The put option gives the right to convert ¥ 2.5 billion at the striking price of ¥ 240/$, yielding $10.42 million rather than the $10 million available from converting ¥ 2.5 billion at the spot rate of ¥ 250/$. Thus by converting $10 million to yen at the spot rate and then selling the yen at the option's striking price there would be a $420,000 gain.

Had the potential foreign currency exposure been hedged by a forward contract but then failed to materialize because the bid was not accepted, the obligation to engage in the forward transaction nevertheless would have remained. In such a situation the losses (or gains) from closing out the forward positions could be very large and, in any case, would be unknown until the time that the bid is rejected. In contrast, the cost of an option contract is limited to the premium and is thus known at the time of purchase. 1/ Furthermore, use of an option contract therefore allows one to incorporate fairly complete and certain hedging costs into initial construction of the bid.

3. Foreign currency option premiums
   and related terminology

The premium paid on an option contract is usually considered to comprise two elements: the intrinsic value and the time value. The intrinsic value represents the value of executing the option immediately. The difference between the premium on an option and its intrinsic value is called the time value. The time value represents compensation for the possibility that the option will have a higher intrinsic value in the future. In the preceding example when the U.S. firm purchased the ¥ 2.5 billion put option with a striking price of ¥ 240/$, the current spot rate was ¥ 250/$. Thus, had the option been executed immediately it would have been worth about $420,000. 2/ In such a case, the put option is said to have a positive intrinsic value. The put option would have a positive intrinsic value whenever the yen depreciates relative to the striking price. In that event, the option allows the holder to sell the foreign currency at a more expensive price than in the

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1/ Since the buyer of an option pays the entire premium up front, he is not subject to margin calls. If forward cover is obtained by means of a futures contract, both the buyer and seller of a futures contract must deposit initial margins and are subject to additional margins as the price of the futures contract changes. Similarly, the seller of an uncovered exchange-traded option is subject to both an initial margin requirement and additional margin calls if the market moves against him.

2/ As previously noted, the put option gives the right to convert ¥ 2.5 billion at the striking price of ¥ 240/$, yielding $10.42 million rather than the $10 million available from converting ¥ 2.5 billion at the spot rate of ¥ 250/$.

spot market. For the call option example, the opposite is the case. In that illustration, the call option would have a positive intrinsic value whenever the Deutsche mark appreciates relative to the striking price. In that event, the option allows the holder to buy the foreign currency at a cheaper price than in the spot market. When the call option was purchased the intrinsic value was zero since the spot rate and striking price were identical.

When the intrinsic value of an option is positive, the option is said to be "in the money," otherwise the option is "at the money" (when the spot rate and striking price are identical) or "out of the money." It may be noted that the premium for a foreign currency option must always be at least as large as its intrinsic value. If a premium was less than the intrinsic value, the option could be purchased and executed immediately and there would be a riskless arbitrage opportunity which would drive premiums higher.

III. Market Arrangements

Foreign currency options are now bought and sold either on an over-the-counter basis, analogous to forward exchange markets, or in organized trading on exchanges, analogous to futures markets. The first part of this section discusses over-the-counter options. One of the advantages of over-the-counter options is that they can generally be "customized" to meet specific needs, such as hedging an odd-sized amount of foreign exchange exposure or hedging exposure in a currency for which standardized contracts are not traded on organized exchanges. The diversity in over-the-counter options contracts (just as with forward contracts) means, however, that they are not readily tradable and that cancelling a deal requires agreement from the original contracting party. The information available on over-the-counter options is, unfortunately, rather sketchy and no comprehensive source for details is available. By comparison, standardized foreign currency option contracts (just as with futures contracts), such as those traded on organized exchanges, can be easily bought and sold, and open positions can, therefore, be more easily squared. Standardized contracts might have particular appeal to speculators who frequently go in and out of the market. For hedgers, although the size of a standard contract may not correspond to their needs exactly, costs in premiums are usually reduced as would be expected by accepting a standardized contract rather than a tailor-made one. The second part of this section discusses foreign currency options trading on organized exchanges and focuses on trading on the Philadelphia Stock Exchange, the exchange which has the highest trading volume at present. 1/

1/ The author is grateful to the Philadelphia Exchange for supplying the data on foreign currency options trading on that exchange.

1. Over-the-counter foreign currency options

Banks in the United States (both commercial and investment banks) started writing customized foreign currency options for their customers before foreign currency options trading began on organized exchanges. According to some sources, U.S. banks usually sold these over-the-counter options contracts to clients only when they requested them as an alternative to a forward contract. 1/ It is also reported that banks build into the option's premium a heavy time value for writing the contract, and because of this the actual volume of over-the-counter activity in the United States might have been rather limited, despite considerable interest in foreign currency options expressed by U.S. businesses. 2/ One problem from a bank's standpoint is the uncertain foreign exchange exposure created by selling an option; a bank cannot know the size of its exposure until the holder either exercises the option or lets the option expire. A perfect hedge for selling an option is, of course, buying an identical one. U.S. banks have reportedly contributed to the development of exchange-traded options by using those options to hedge some of the foreign exchange exposure they take on writing options for their customers.

Swiss banks and finance houses also started offering customized foreign currency options before trading on organized exchanges began. They now regularly offer contracts on three exchange rates (the U.S. dollar/Swiss franc, the U.S. dollar/Deutsche mark, and the Deutsche mark/Swiss franc), and the larger Swiss banks have reportedly begun to trade over-the-counter options among themselves, offering quotes on contracts that are standardized by maturity date and contract size. Smaller banks in Switzerland do not directly make markets in foreign currency options but apparently buy contracts from the big banks and sell them at a commission to their customers. 3/ An indication that foreign currency options may be attracting some increasing attention was an announcement by one of the major banks that it planned to expand the types of contracts it offers, most likely to include pound sterling/U.S. dollar and pound sterling/Swiss franc options. 4/

London is a third important source of over-the-counter foreign currency options. As in Switzerland, an interbank currency option market is developing, and in July 1984 a formalized trading system was inaugurated which reportedly allows banks to post prices anonymously on trading screens (such as Reuters and Telerate) as a means to reaching

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1/ See Financial World, October 3-16, 1984, p. 23.
2/ See Andrews, "Recent Trends in the U.S. Foreign Exchange Market," Federal Reserve Bank of New York Quarterly Review, Summer 1984, p. 44.
3/ The information on Switzerland has been taken from "Financial Spotlight Swiss Currency Options," Reuters News Service, October 3, 1984.
4/ "Swiss Bank Corporation Plans New Foreign Currency Options," Reuters News Service, November 15, 1984.

a larger market. 1/ The Bank of England has appeared to be sympathetic toward the expansion of a London interbank market in foreign currency options and willing to foster the standardization of contracts in the interest of developing a true secondary market. 2/

2.   Organized markets

Trading in foreign currency options on organized exchanges is a relatively new development, having begun on the Philadelphia Stock Exchange in December 1982. Since then, trading in such options has also begun on the Chicago Mercantile Exchange, the European Options Exchange in Amsterdam, and the Montreal Exchange in Canada—all of which trade so-called American options exclusively. Just recently, on May 16, 1985, the London Stock Exchange also began trading foreign currency options, as did the London International Financial Futures Exchange on June 27, 1985. 3/ Other exchanges also plan to start foreign currency options trading for the first time. 4/ The discussion will focus first on the oldest and largest of the organized market, the one in Philadelphia.

1/ The set-up appears to be similar to various brokered money and securities markets in the United States. The Bank of America, Barclays International, Citibank, Fidelity Bank, Hambros, Hill Samuel, Lloyds, Marine Midland, National Westminster and Standard Chartered are among the banks reported to be active in the foreign currency options business in London.

2/ "U.K. Move for Interbank Foreign Currency Options Market," London Financial Times, July 3, 1984. A Bank of England official expressed the view that traded options could play a much larger role in coping with the increased volatility of financial markets, but only if they are closely regulated. See "Bank of England View on Options Regulation," Reuters News Service, March 25, 1985.

3/ The size of the American-style U.S. dollar/pound sterling option contracts that began to be traded on May 16 is £12,500. On June 20, 1985, the London Stock Exchange began trading U.S. dollar/Deutsche mark option contracts, the size of these latter contracts being set at DM 62,500. The London International Financial Futures Exchange (LIFFE) started trading on June 27 U.S. dollar/pound sterling option contracts on £25,000.

4/ The Chicago Board Options Exchange has said that it filed with the U.S. Securities and Exchange Commission to trade options on foreign currency. The six options planned for trading beginning in September will be on £25,000, DM 125,000, Sw F 125,000, Can$100,000, ¥ 12,500,000 and F 250,000, and the contracts will be written as European options. See "CBOE Files with SEC to Trade Currency Options," Reuters News Service, December 14, 1984 and International Financing Review, Issue 575, June 15, 1985, p. 1389. The Singapore International Monetary Exchange also plans to introduce trading in foreign currency options. See "SIMEX Plans to Introduce Trading in New Options," Reuters News Services, February 28, 1985.

When the Philadelphia Exchange started trading currency options in December 1982, only pound sterling option contracts were listed but the Japanese yen, the Swiss franc, the Deutsche mark, and the Canadian dollar were added within three months, and in September 1984 a new option contract on French francs was added. The sizes of the option contracts are standardized at £12,500, DM 62,500, Sw F 62,500, ¥ 6,250,000, Can$50,000 and F 125,000, and the expiration dates are set at the second Saturday of March, June, September, and December. Foreign currency options on the Philadelphia Exchange open with terms to maturity of three, six, and nine months, and the striking price is stated in U.S. dollars per unit of foreign currency.

Some examples are given below to introduce in more detail foreign currency put and call options quoted on the Philadelphia exchange. These examples also serve to illustrate further the terms "in the money" and "out of the money."

Call options

- A call option on Deutsche mark giving one the right to purchase DM 62,500 at a striking (or exercise) price of $0.36 per Deutsche mark on or before the second Saturday in September traded for a premium of $0.0124 per Deutsche mark, or $775, on June 18, 1984. The spot dollar/Deutsche mark exchange rate on June 18 was $0.3631/DM and the option had, therefore, an intrinsic value of $194. The option is said to be in the money, representing a positive intrinsic value.

- A DM 62,500 call option with a striking price of $0.36 per Deutsche mark and an expiration date in March 1985 traded for a premium of $0.0056 per Deutsche mark, or $350, on October 23, 1984. The spot dollar/Deutsche mark exchange rate on October 23 was $0.3304/DM. The option was out of the money because it had negative intrinsic value.

- A call option identical to the one in the previous example, except with a striking price of $0.37 per Deutsche mark, traded for a premium of $0.0035 per Deutsche mark, or $219. The option was further out of the money than the one in the preceding example because the intrinsic value was lower; the option also traded for a smaller premium as a result.

Put options

- A put option on pound sterling giving one the right to sell £12,500 at a striking price of $1.40 per pound sterling on or before the second Saturday in March 1985 traded for a premium of $0.0465 per pound sterling, or $581, on June 18, 1984. The spot dollar/pound sterling exchange rate on June 18 was $1.3765/£ and the option had, therefore, an intrinsic value of $294 and was in the money.

- A £12,500 put option with a striking price of $1.25 per pound sterling and an expiration date in March 1985 traded for a premium of $0.0670 per pound sterling, or $838, on October 23, 1984. The spot dollar/pound sterling exchange rate on October 23 was $1.2178 and so the option was in the money with an intrinsic value of $403.

- A put option identical to the one in the previous example, except with a striking price of $1.30 per pound sterling, traded for a premium of $0.1040 per pound sterling, or $1,300. The option was, therefore, further in the money than the one in the preceding example because it had a higher intrinsic value; the option also traded for a larger premium as a result.

Trading volume was initially fairly low on the Philadelphia Exchange, but began to pick up markedly after the first year. As shown in Table 1, the average volume of foreign currency options traded on the Philadelphia Exchange did not reach 1,000 contracts a day until September 1983, i.e., after the first nine months of trading, but the volume doubled in the next four months and exceeded 5,000 contracts a day in March and again in June of 1984. Trading volume has continued to grow markedly since then, peaking at over 19,000 contracts in February 1985 and averaging over 15,000 contracts in July 1985, the latest month of data.

Table 2 measures trading volume by outstanding contracts or "open interest," a gauge which emphasizes the depth of the market. As shown in the table, open interest peaked at over 400,000 contracts at the end of May 1985, almost a fivefold increase from its year earlier level, and stood at over 300,000 contracts in July 1985.

European customers are reportedly a party to more than half the foreign currency options traded on the Philadelphia Exchange. 1/ Interestingly enough, trading activity in foreign currency options on the European Options Exchange has been comparatively low. 2/ The appeal of the Amsterdam Exchange may be limited by the small number of currencies for which contracts are available and the relatively small sizes of the contracts. The European Exchange trades only three options,

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1/ See "The Philadelphia Success Story", London Financial Times, October 2, 1984, and "A New Act in the Philadelphia Story", Financial World, October 3-16, 1984.

2/ Although data on trading volume have not been obtained for the European Options Exchange or the Montreal Exchange, conversations with economists at commercial banks and various articles in the financial press indicated that the Philadelphia options have considerably higher trading volume than those on other exchanges, perhaps with the exception of the Canadian dollar option traded in Montreal.

Table 1. Average Daily Volume of Foreign Currency Options
Trading on the Philadelphia Stock Exchange

(Number of contracts)

Month		Number of contracts
1982	Dec.	226
1983	Jan.	427
	Feb.	318
	Mar.	304
	Apr.	476
	May	658
	Jun.	753
	Jul.	465
	Aug.	848
	Sept.	1,343
	Oct.	1,327
	Nov.	1,009
	Dec.	1,376
1984	Jan.	2,744
	Feb.	3,779
	Mar.	5,410
	Apr.	2,921
	May	4,728
	Jun.	5,264
	Jul.	7,078
	Aug.	6,333
	Sept.	7,903
	Oct.	8,202
	Nov.	9,243
	Dec.	6,041
1985	Jan.	10,675
	Feb.	19,012
	Mar.	17,941
	Apr.	17,809
	May	18,322
	Jun.	16,319
	Jul.	15,007

Source: Data provided by the
Philadelphia Stock Exchange.

Table 2. Month-End Open Interest in Foreign Currency
Options on the Philadelphia Stock Exchange

(Number of contracts)

Month		Number of contracts
1982	Dec.	1,763
1983	Jan.	2,867
	Feb.	3,961
	Mar.	4,175
	Apr.	8,877
	May	15,166
	Jun.	13,293
	Jul.	17,276
	Aug.	25,644
	Sept.	26,422
	Oct.	35,290
	Nov.	34,562
	Dec.	29,258
1984	Jan.	52,705
	Feb.	73,120
	Mar.	65,474
	Apr.	68,228
	May	84,810
	Jun.	67,122
	Jul.	98,311
	Aug.	142,245
	Sept.	121,508
	Oct.	180,696
	Nov.	210,901
	Dec.	132,230
1985	Jan.	219,844
	Feb.	314,970
	Mar.	266,018
	Apr.	340,461
	May	403,127
	Jun.	249,910
	Jul.	319,721

Source: Data provided by the
Philadelphia Stock Exchange.

one on $10,000 with payment in Netherlands guilders, another of the same dollar size with payment in Deutsche mark, and a third on £5,000 with payment in U.S. dollars. 1/ As on the Philadelphia Exchange, option contracts are issued with maturities of three, six, and nine months with expiration dates set in March, June, September and December.

Foreign currency options contracts traded on the Montreal Exchange are issued with the same maturities and expiration dates as those traded on the Philadelphia and European Exchanges. The Montreal Exchange now trades five options, one on $100,000 payable in Canadian dollars, two others of the same U.S. dollar size but one payable in Deutsche mark and the other payable in Swiss francs, a fourth contract on £100,000 payable in U.S. dollars, and finally one on Can$50,000 payable in U.S. dollars. 2/

The Chicago Mercantile Exchange has also begun trading in foreign currency options, but its contract differs from those traded on the other exchanges. The options contract that has traded in Chicago since January 1984 is an option on a DM 125,000 futures contract. The Chicago foreign currency option gives the right to buy or sell a DM 125,000 futures contract at any time up to the option's expiration date at the option's striking price. 3/4/ In other words, the holder of the option contract would receive or provide for delivery of a futures contract in the currency rather than delivery of the foreign exchange itself. Since futures prices are closely correlated with spot exchange rates, an option on a foreign currency futures contract can be seen to be as

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1/ The European Options Exchange reportedly hopes to launch a contract on the European Currency Unit (ECU) later this year. See "EOE Considers ECU Options Contract," London Financial Times, March 26, 1985.

2/ All premium payments on the Montreal Exchange used to be in U.S. dollars. The size of the options contract were also generally smaller than those traded in Philadelphia, with contracts previously standardized at £5,000, DM 25,000, Sw F 25,000, ¥ 2,500,000, and Can$50,000. In December 1984, trading stopped on all these contracts except for the Can$50,000 contract. In March 1985, larger U.S. dollar/pound sterling and U.S. dollar/Canadian dollar contracts were introduced, and a larger U.S. dollar/Deutsche mark contract was introduced in April 1985. In July 1985, the U.S. dollar/Swiss franc option was introduced. The Montreal Exchange has said that it also plans to reintroduce contracts involving the Japanese yen in a size larger than the one traded before.

3/ The price of a DM 125,000 futures contract is quoted in terms of U.S. dollars per Deutsche mark. For example, a futures contract priced at .3400 reflects a dollar value of $42,500 (i.e., DM 125,000 multiplied by .3400). When the exercise price of a call option is higher (lower) than the price of the underlying futures contract, the option is out of (in) the money. Conversely, when the exercise price of a put option is higher (lower) than the price of the underlying futures contract, the option is in (out of) the money.

4/ If delivery of the futures contract is taken, that contract can either be closed out immediately, or it can be held to maturity.

effective a hedging device for most purposes as an option on foreign
currency itself. The expiration dates are once again in March, June,
September, and December, but the options expire 12 days before the
expiration of the underlying futures contract (on the third Wednesday
of the contract month).

Trading in options on Deutsche mark futures in the Chicago market
has grown briskly. As shown in Table 3, the average daily volume of
trading in its DM contract increased to almost 5,000 contracts by
November 1984, the eleventh month of trading, and peaked at over 9,000
contracts by February 1985 before declining in the subsequent months to
stand at roughly 7,000 contracts in July 1985. Open interest, shown
in Table 4, rose fairly steadily to about 86,000 contracts at the end
of May 1985, showing declines only in June, September and December
of the previous year and in March 1985 as contracts naturally expired;
open-interest stood at about 62,000 contracts in July 1985, following
a sharp decline in the previous month when more contracts naturally
expired. 1/ The Chicago Mercantile Exchange recently began trading
options on the pound sterling and the Swiss franc futures contracts
on February 25, 1985. 2/

IV. More on the Uses of Options as a Tool for Hedging and for Position-taking in the Foreign Exchange Market

As noted earlier, foreign currency options do not entail an obli-
gation to their holder and, consequently, they provide more flexibility
in risk management than forward or futures markets. An option is
also a better hedge against a contingent or uncertain foreign exchange
exposure. One additional advantage of the so-called American foreign
currency options is that they allow the holder to remain flexible with
respect to the timing of anticipated foreign currency inflows, as the
option can be exercised at any time up to the maturity date. A forward
or futures contract, by contrast, binds the participants to undertake
in a foreign currency transaction on a given day and at the given
exchange rate.

The choice of a striking price is a further attraction of foreign
currency options, which allows the purchaser to take into account his

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1/ The Deutsche mark options contract traded in Philadelphia is not
strictly comparable. The size of the contract is smaller at DM 62,500
and, of course, it calls for physical delivery of the foreign currency,
not of a futures contract. Nevertheless, to give some comparison
between Deutsche mark options trading on the two exchanges, the average
daily volume was about 3,500 contracts in July 1985 in Philadelphia and
open interest at the end of July was around 71,000 contracts.

2/ After about only five months of trading, the average daily volume
of trading in its option on a £25,000 futures contract reached about
1,900 contracts in July 1985 and open interest at the end of that month
hit about 25,000 contracts. For its option on a Sw F 125,000 futures
contract, average daily volume and month end open interest for July
reached about 2,000 contracts and 20,500 contracts respectively.

Table 3. Average Daily Volume of Trading
in Options on Deutsche Mark Futures on the
Chicago Mercantile Exchange

(Number of contracts)

Month		Number of contracts
1984	Jan.	519
	Feb.	2,091
	Mar.	2,643
	Apr.	2,212
	May	3,311
	Jun.	2,699
	Jul.	3,057
	Aug.	2,420
	Sept.	4,292
	Oct.	3,159
	Nov.	4,868
	Dec.	3,333
1985	Jan.	4,516
	Feb.	9,407
	Mar.	7,258
	Apr.	7,269
	May	6,841
	Jun.	3,849
	Jul.	6,704

Source: IOM Daily Information Bulletin,
Index and Option Market Division of the
Chicago Mercantile Exchange, various
bulletins. Data for October 1984
through July 1985 were kindly provided
by telephone by the Statistics Department
of the exchange.

Table 4. Month-End Open Interest in Options
on Deutsche Mark Futures on the
Chicago Mercantile Exchange

(Number of contracts)

Month		Number of contracts
1984	Jan.	n.a.
	Feb.	12,205
	Mar.	22,039
	Apr.	30,054
	May	41,586
	Jun.	28,177
	Jul.	37,636
	Aug.	45,591
	Sept.	34,603
	Oct.	45,009
	Nov.	55,012
	Dec.	35,543
1985	Jan.	57,389
	Feb.	88,048
	Mar.	54,548
	Apr.	75,069
	May	85,798
	Jun.	41,827
	Jul.	62,239

Source: IOM Daily Information Bulletin,
Index and Option Market Division of the
Chicago Mercantile Exchange, various
bulletins. Data for October 1984
through July 1985 were kindly provided
by telephone by the Statistics Department
of the Exchange.

exchange rate expectations and tolerance to risk. A hedger could take
an at-the-money option in which the current spot exchange rate and
striking price are the same, but if he expects the currency to move in
his favor or he is willing to take some risk, he could go for an out-of-
the-money option in order to save on the premium. 1/ At the extreme, a
hedger who requires protection only against a major adverse swing in the
exchange rate might go for a far out-of-the-money option contract (in
essence, disaster insurance) which would have a very low premium. By
contrast, a forward or futures contract provides a choice of only whether
or not to buy at a given premia/discount on the spot exchange rate.

When a new foreign currency option contract is listed for trading
on the Philadelphia Exchange, there are at least four put and four call
striking prices, expressed in terms of U.S. dollars per unit of foreign
currency, around the prevailing spot exchange rate. The striking prices
for the pound sterling are in five-cent intervals, for the French franc
in one-tenth of a cent intervals, for the Japanese yen in intervals of
a hundredth of a cent, and in one-cent intervals for the other curren-
cies. If spot exchange rates subsequently change by sufficiently large
amounts, new options may be declared eligible for trading. Striking
prices are also expressed in terms of U.S. dollars per Deutsche mark
on the Chicago Mercantile Exchange. When trading in a new Deutsche mark
option contract opens on that exchange, five put and five call striking
prices are listed, including the nearest whole cent to the underlying
futures price, the next two higher and the next two lower to the under-
lying futures price.

Foreign currency options broaden the ways in which positions can be
taken on foreign exchange rates. As previously noted, options leave poten-
tial gains virtually unconstrained while limiting potential losses to the
premiums already paid. Options also add a new dimension to position-taking
(speculation) by facilitating positions not only on the level of exchange
rates but also on the volatility of exchange rates. 2/

1/ The next section discusses in more detail the determination of an
option's premium. It may be noted here, that an out-of-the-money option
has a lower premium than an in-the-money option, everything else equal,
and the farther out of the money an option is, the lower the premium.

2/ Speculation can, of course, play an important role in developing and
ensuring the liquidity of a market, and the options market may attract
speculators because it adds, as discussed below, a new dimension for their
position-taking on foreign exchange rates. Furthermore, on the one hand,
increased volatility in foreign exchange rates can add to the demand for
options on the part of speculators as well as hedgers, thus helping the
options market to grow. The intent of this section is to briefly highlight
the possible attraction of foreign currency options in this regard. On
the other hand, however, whether, and the extent to which, speculation
itself on foreign exchange rates, via spot or forward markets, leads to
greater exchange rate volatility is an open-ended question. The intent
of this section is not to determine the extent to which the options
market might encourage more and varied speculation than might otherwise
exist, or to determine whether speculation via the options market may
add to exchange rate volatility.

There are a number of complex strategies which combine puts and calls
in different amounts, at different striking prices and for different matu-
rities, but the basic technique for taking a position on the volatility
of a currency is called a straddle. By buying a put and a call option on
the same currency at the same exercise price and for the same time period,
profits are made if the exchange rate rises or falls enough to move out-
side of a certain range. To make a profit, the foreign currency has to
be sufficiently stronger than the exercise price in which case the call
option gains in value or sufficiently weaker than the exercise price in
which case the put option gains in value to more than compensate for the
two premiums paid. 1/ Another basic strategy for speculating on exchange
rate volatility is called a strangle; it differs from a straddle in that
the striking prices on the put and call options are not the same. In a
strangle, one buys both a put and a call option that are each in the
money, hence a greater change in exchange rates has to occur to compensate
for the higher premiums and yield an overall profit. By varying the
striking prices and the number of contracts purchased under these and
other strategies, positions can be taken both on the volatility and the
future level of the exchange rate. 2/ Thus, the addition of an options
market allows for much more complex foreign exchange strategies than
were previously available.

V. The Valuation of Foreign Currency Options and the Relationship Between Options and Other Foreign Exchange Markets

In this section factors that influence the premium for a foreign
currency option are examined and arbitrage relationships between the
options and other foreign exchange markets reviewed. The analysis of
pricing is undertaken only for call options since the pricing of put
options would be similar but viewed from the opposite direction. Six
variables play important roles in determining the premium on (also
referred to as the pricing of) a foreign currency option: these are
the level and volatility of the spot exchange rate, the domestic and
foreign interest rates, the striking price, and the time remaining to
the expiration date of the contract. Initially, a range for the
premium on a foreign currency option is calculated based only on the
spot exchange rate, the striking price, and interest rates. Other
factors are incorporated later in an exact pricing formula.

1/ Suppose, for example, that both a put and a call option on
DM 62,500 are purchased, each with a striking price of $0.33/DM.
Suppose further that the premium for the call option is $700 and $550
for the put option so that the total for the two premiums paid comes to
$1,250. If the Deutsche mark appreciates to $0.35/DM or higher, the
call option would be worth at least $1,250, that is ($0.35/DM - $0.33/DM)
multiplied by DM 62,500. If the Deutsche mark depreciates to $0.31/DM
or less, the put option would be worth at least $1,250.

2/ For example, if one buys two calls and a single put at the same
exercise price for the same maturity, one is betting on volatility,
but also that the currency is more likely to rise than fall.

1. Pricing foreign currency options

Following Grabbe (1983), two hypothetical portfolios are carefully chosen to derive a range for the premium on a foreign currency call option. 1/

  (i) Portfolio One: Purchase for $c(s,S,t,T)$ a European call option where c is the domestic currency premium at time t of the option which expires in T units of time and which has a striking price (in units of domestic currency per units of foreign currency) of S as compared to the spot rate at time t of s. At the same time purchase S domestic currency bonds maturing in T units of time at the price $B(t,T)$, the domestic currency price of a pure discount bond which pays one unit of domestic currency at maturity.

  (ii) Portfolio Two: Purchase one foreign currency bond maturing in T units of time at a domestic currency price of $sB^*(t,T)$ where B^* is the foreign currency price of a pure discount bond which pays one unit of foreign exchange at maturity.

It can be shown that for any future spot rate the payoff to the first portfolio will always be as large or larger than that on the second, and consequently the cost of the first one must, in equilibrium, be at least as great as that of the second. Thus,

$$c(s,S,t,T) + SB(t,T) \geq sB^*(t,T) \quad \text{or}$$

$$c(s,S,t,T) \geq sB^*(t,T) - SB(t,T) \qquad (1)$$

And since an American call option has all the same features as a European call option plus the additional one that it can be exercised at any time, it must be at least as valuable. Therefore,

$$C(s,S,t,T) \geq c(s,S,t,T)$$

$$\geq sB^*(t,T) - SB(t,T) \qquad (2)$$

1/ Grabbe, J. Orlin, "The Pricing of Call and Put Options on Foreign Exchange," Journal of International Money and Finance (1983), 2, pp. 239-253.

where C is the premium for an American call option. 1/ Moreover, it can be shown that the call option must have a premium at least as great as the present discounted value of the difference between the forward exchange rate and the striking price. The covered interest parity condition implies that $F(t,T) = sB^*(t,T)/B(t,T)$ where $F(t,T)$ is the forward exchange rate at time t for the maturity T. By substituting $F(t,T)B(t,T)$ for $sB^*(t,T)$ in inequality (2) and rearranging terms we get

$$C(s,S,t,T) \geq B(t,T)(F(t,T) - S) \qquad (3)$$

Since a holder is never forced to exercise an option, it cannot be so unattractive that people must be paid to take it. Thus, a stronger inequality than (2) can be obtained by noting that the value of an option must be positive and by further noting that it must be at least equal to its intrinsic value to avoid riskless arbitrage profits. Thus,

$$C(s,S,t,T) \geq \text{maximum of} \begin{cases} 0, \text{ or} \\ s-S, \text{ or} \\ sB^*(t,T)-SB(t,T) \end{cases} \qquad (4)$$

This inequality highlights the fact that a change in either the spot rate, the exercise price, or interest rates may influence an option's premium. A rise in the spot exchange rate (appreciation of the foreign currency), all else equal, tends to raise the premium, as does a decline in the striking price. Intuitively, in both cases the premium tends to increase because the intrinsic value of the option is higher. A rise in the domestic interest rate (fall in B) or a fall in the foreign interest rate (rise in B*), all else equal, also tend to raise the premium. The combined effect of interest rate changes on the value of a foreign currency option will, however, be ambiguous in general because not only do changes in interest rates directly change B* and B, but usually also the spot rate.

Within the range given in inequality (3), other factors come into play to influence an option's premium; in particular, the volatility of the spot exchange rate and the time to maturity of the contract are important. An exact pricing equation is presented below for the premium on a European foreign currency call option. It should be noted that at present, no simple solutions for exact pricing formulas for

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1/ As an example, if one-year domestic bonds have an interest rate of 11.25 percent then $B(t,1) = 1/1.1125 = 0.8989$. If one-year foreign bonds, say Swiss franc bonds, have an interest rate of 5.75 then $B^*(t,1) = 1/1.0575 = 0.9456$. Assuming a spot dollar price of Swiss francs, s, of \$0.55/Sw F, a one-year American option on one Swiss franc with a striking price, S, of \$0.50 will have a premium C (0.55, 0.50, t, 1) greater than or equal to $(0.55)(0.9456) - (0.50)(0.8989) = \$0.0706$.

American options have been solved. [1] Nevertheless, participants
in the foreign currency option markets use the formula given below in
evaluating premiums for American options, even though it is not precise.

To derive an exact pricing equation for the premium on a European
foreign currency option, a number of assumptions must be made about
the paths that the spot exchange rate and interest rates will tend to
follow, as well as about their interaction over time. One of the most
frequently used pricing formulas is derived by Garman and Kohlhagen
(1983). [2] They assume, inter alia, that the spot exchange follows a
type of random process [3], that markets are frictionless, and that
interest rates in domestic and foreign markets are constant. Under
these assumptions, the price of a call option on foreign currency
may be written as [4]

$$c = e^{-r_f T} sN(d_1) - e^{-r_d T} SN(d_2) \qquad (5)$$

where $d_1 = (\ln(s/S) + (r_d - r_f + 1/2\ \sigma^2)T)/\ \sigma/\overline{T}$

$d_2 = d_1 - \sigma\ /\overline{T}$

r_d = domestic interest rate

r_f = foreign interest rate

σ^2 = the instantaneous variance of the spot
exchange rate

N(.) = the normal distribution function

ln is the natural logarithm, e is the exponential,
and, as before, s is the spot exchange rate, S is the
striking price, and T is the time remaining to
maturity.

The forward rate is incorporated into the pricing equation by using
the covered interest rate parity condition, linking the premium

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[1] Approximate solutions may be found numerically.

[2] Garmen, Mark B. and Steven W. Kohlhagen, "Foreign Currency Option
Values," Journal of International Money and Finance, 1983, 2, pp. 231-
237.

[3] The differential representation of spot price movements is
ds = μsdt + σsdz where z is the standard Wiener process and σ^2 is the
instantaneous variance of the spot exchange rate.

[4] Grabbe (1983) allows interest rates to be stochastic and derives
a similar formula.

explicitly to both the forward and spot exchange rates:

$$c = e^{-r_d T} [FN(d_1) - SN(d_2)] \qquad (6)$$

where

$$d_1 = (\ln(F/S)) + (1/2\, \sigma^2 T))/\sigma\, \sqrt{T}$$

$$d_2 = d_1 - \sigma/\sqrt{T}$$

F = dollar price of forward foreign currency

Under the exact pricing formula (5), an increase in the spot exchange rate or a decline in the striking price will raise the premium for the option as in our previous analysis. A rise in the domestic interest rate or a fall in the foreign interest rate will also raise the premium, while the combined effects of changes in interest rates remain ambiguous. In addition, equation (5) introduces terms for the variability of the spot exchange rate (the instantaneous variance, σ^2) and the time to expiration (T). As it turns out, increases in both tend to increase the value of the option. The intuition is that the longer the time until the option expires, the greater the probability that the spot exchange rate will appreciate relative to the striking price over the life of the contract and, therefore, the greater is the chance that the call option will increase in intrinsic value over that period. Also, the greater the exchange rate volatility is the greater is the probability that the spot exchange rate will appreciate relative to the striking price and, therefore, the greater is the chance that the call option will increase in intrinsic value over time. In general, the longer the option has to run before expiration and the higher the volatility of the spot exchange rate, the greater the time value of the option.

2. Arbitrage relationship between options
    and other foreign exchange markets

The exact pricing formula presented above for a European call option establishes a link between different segments of foreign exchange markets. That link, however, holds exactly only under some strong assumptions which may not hold in actual market conditions, and it holds only for the European option to which the formula applied. The formula can, nevertheless, be taken as a useful guide for determining those factors which influence market prices. This section derives looser arbitrage relationships between the options and forward markets that do not depend on the special assumptions needed to derive an exact pricing formula.

A strategy of simultaneously buying a call option and selling a put option, both for the same expiration date and striking price, matches the pattern of gains and losses on a forward contract to purchase the foreign currency on the same expiration date at an exchange rate equal to the striking price. 1/ Thus, the price for buying one unit of the foreign currency forward by using the position in options is

$$S + (C-P)(1+i) \qquad (7)$$

where S is the striking price, C is the premium paid for the call option and P is the premium received for the put option, measured in domestic currency cost per unit of the foreign currency. The difference between the premiums in expression (7), (C-P), is multiplied by one plus the interest rate, (1+i), to take into account the interest cost of borrowing (return from investing) the excess (shortfall) of the premium paid for the call over the premium received for the put over the life of the contracts. If the cost of buying foreign currency using this options strategy is less expensive than buying it using a forward contract at the forward rate (F) then profits ($\sqcap$) can be earned by combining the options position with a forward sale to earn 2/

$$\sqcap = F - S - (C-P)(1+i) \qquad (8)$$

If the cost of buying foreign currency using the options strategy turns out to be more expensive than buying it using a forward contract then profits can be earned by combining an options position (this time buying a put and selling a call) with a forward purchase to earn

$$\sqcap = S + (C-P)(1+i) - F \qquad (9)$$

These profits should, however, be driven to zero as price differentials between the forward and options markets that create riskless profits are arbitraged away. In equilibrium, these arbitrage profits are zero.

$$C - P = (F-S)/(1+i) \qquad (10)$$

Equation (10) states that the difference between the forward exchange rate F and the striking price S, discounted by the interest rate, equals the difference between the call and put premiums. By using the

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1/ The holder of this position in options will gain on the call by the amount the spot exchange rate rises above the striking price and lose on the put by the amount the spot exchange rate falls below the striking price.

2/ Transactions costs are, of course, assumed to be zero.

covered interest parity condition, the difference between the call and put option premiums could alternatively be linked to the spot exchange market and domestic and foreign money markets. 1/

VI. Summary and Conclusions

Foreign currency options are a relatively new financial instrument for managing foreign exchange risks. Because an option contract entails a right rather than an obligation, foreign currency options not only limit the risk to their holders from adverse movements in exchange rates, but also permit gains from advantageous rate movements. Options are particularly useful for hedging uncertain flows of foreign currency, and they represent an innovative way in which foreign exchange positions can be taken. In short, foreign currency options provide an economic agent with an additional choice of ways to reduce foreign exchange rate risks and to potentially profit from exchange rate changes. While foreign currency options do not eliminate exchange rate risks altogether, they do add another dimension to the ways in which such risks can be transferred from one agent to another.

In addition to over-the-counter, or customized, foreign currency options, standardized foreign currency options contracts are available and are traded on a number of organized exchanges. Trading volume in exchange traded options has grown markedly, especially over the last year or so, and it appears to be in the process of further expansion. Some of the exchanges already offering foreign currency options in a limited number of currencies have very recently introduced contracts in additional currencies, while other exchanges have just started or are planning to start trading foreign currency options for the first time. At the same time, an interbank market in options has been developing, facilitating increased bank services to customers and complementing trading on exchanges.

Several factors could support the future development of the foreign currency options market. Rapid growth in international trade could further add to the commercial demand for foreign currency options. The continuation of volatility in exchange rates is another factor, as it tends to stimulate demand from both speculators and hedgers seeking new or additional tools with which to manage exchange risks. In addition, the use of foreign currency options is likely to grow simply because of rising familiarity with the instruments; the more that people use options and become comfortable with them, the larger the market is likely to become. Options trading would also continue to benefit from interaction with the well-developed spot, forward, and futures markets.

1/ It may be noted that the sizes of option contracts on the Philadelphia exchange (£12,500, Can$50,000, DM 62,500, ¥ 6,250,000, Sw F 62,500, and F 125,000) are exactly one-half the contract size of the corresponding currency futures contract traded on the Chicago Mercantile Exchange. The options contract size was tailored to the size of futures contracts to facilitate cross-trading between the two markets and thereby add to options trading volume.