Annex II

Uses of Foreign Exchange Instruments

Trading in the foreign exchange markets takes place for a variety of motives. This annex discusses three aspects of foreign exchange transactions: first, the arbitrage that links the forward and spot markets; next, the use of foreign exchange markets as "synthetic money markets"; and then the use of foreign exchange instruments to hedge foreign currency risk, which covers first the basic hedging techniques typically used by individuals and investors and then the dynamic hedging strategies typically used by banks to hedge exposure associated with issuing currency options. The consequences of these various strategies for foreign exchange market behavior are also examined.

Arbitrage Between the Foreign Exchange and Money Markets

The foreign exchange market is closely linked to the money markets. Many of the important participants in these markets are the same, and the trading and management strategies are similar. Arbitrage between the two markets implies that foreign exchange swaps and forward contracts are priced with reference to interest rate differentials. It also enables central banks to influence the exchange rate through their control of short-term interest rates.

The relationship between foreign exchange markets and money markets is most commonly understood in terms of an interest parity condition. Briefly, arbitrage between foreign exchange and money markets is expected to ensure the maintenance through time of the covered interest parity condition (CIP) in which the forward premium on foreign exchange equals the interest rate differential for deposits of the same maturity. Therefore, if the foreign interest rate exceeds the domestic rate, arbitrage ensures that the price of foreign exchange for forward delivery is below the price for spot delivery.

In practice, this means that the price for forward delivery of foreign exchange is simply quoted on the basis of the interest rate differential: any change in relative interest rates is automatically reflected in the forward discount. It also implies that in turbulent times when interest rates become highly unstable, it may prove difficult to obtain a secure price for forward contracts; in such circumstances, a key tool in a hedging strategy becomes unavailable at a time when hedging foreign exchange risk becomes particularly important.

Synthetic Money Markets

Liquid foreign exchange markets greatly expand the range of possible sources and uses of funds available to an individual borrower or investor. For example, a firm that expects to receive deutsche mark in the future but needs dollars today can use the German money market to borrow deutsche mark against the receivable and buy dollars; alternatively, it can sell deutsche mark forward for dollars and borrow dollars on the U.S. money market, using both the deutsche mark receivable to settle the forward deal and the dollars purchased to repay the U.S. loan. The second alternative effectively replicates, or synthesizes, a German money market loan. But the creation of a synthetic money market instrument itself requires the foreign exchange market and, in this case, the U.S. money market to be highly liquid markets.

The liquidity of the money markets and the foreign exchange markets are therefore closely related. The relatively large volume of trading in U.S. money market instruments makes this market attractive for international investors, thereby increasing the foreign demand for U.S. dollar transactions and the liquidity of U.S. dollar foreign exchange markets. This in turn makes it even more attractive for foreigners to transact in the U.S. money markets—further increasing the liquidity of those money markets. The high liquidity of the U.S. dollar foreign exchange market also contributes to the efficacy of the dollar as a vehicle currency—making roundabout transactions less costly in relation to direct ones. Liquidity breeds liquidity.

These links between the money market and the foreign exchange market help explain the preeminence of the U.S. dollar as the vehicle currency, as well as the large volume of wholesale business relative to retail business.

Hedging Foreign Exchange Exposure

Basic Elements of Hedging

The foreign exchange market provides facilities for hedging risks associated with exchange rate

movements. The essence of hedging is that an investor anticipating a receipt in foreign currency takes a short position to offset it. Conversely, a long position can be used to hedge risks associated with future payment obligations.

The array of foreign exchange instruments characterized in Annex I presents several alternative hedging strategies. A firm that expects, for example, to pay foreign currency in one month's time faces the risk that it may pay more than it expected if that currency appreciates in the meantime. It could eliminate this risk by acquiring the foreign currency in the spot market and holding it for a month. An alternative would be to buy the currency forward for delivery in one month. If the foreign currency appreciates, the increased domestic currency value of the future payment is exactly offset by an increase in the value of the foreign currency held or of the forward contract. Likewise, if the currency depreciates, the decline in value of the liability is offset by a decline in value of the foreign currency asset. This eliminates the possibility of unexpected gains as well as unexpected losses.

The same firm may also purchase a futures contract in which it acquires the right to receive foreign currency at a price specified in the contract. In most cases, the futures contract is not presented for delivery, but is "closed out" when the firm sells it back to its issuer or to another investor. The profit or loss on the sale of the contract offsets the appreciation or depreciation in the exchange rate. For example, if the currency appreciates beyond the exchange rate specified in the contract, the extra cost of acquiring the foreign exchange on the spot market will be exactly offset by an increase in the value of the futures contract.

Alternatively, the firm may decide to try to protect itself only against appreciation of the foreign currency. This could be accomplished by purchasing a call option, which gives the firm the right to acquire foreign currency at an agreed price. If the spot exchange rate on maturity of the contract exceeds the strike price, then the firm would exercise the option or sell it back to the issuer at a profit equal to the extra cost of purchasing the currency on the spot market. If the spot price is less than the strike price, the firm would simply allow the option to expire unused. Hence, the option allows the firm to set a maximum on the cost of foreign currency needed to meet its obligation.

A hedge will completely eliminate currency risk only if the security underlying the hedge is identical to the security whose return is being hedged. For example, a U.K. investor could hedge holdings of U.S. Treasury bills by buying futures or options on these treasury bills. However, treasury bill futures will not generally provide a perfect hedge if the assets are U.S. corporate bonds, even if they have the same maturity. Even if the assets being hedged are treasury bills, they may have different maturities or coupons than the treasury bills underlying the futures contract. These differences between the asset or liability being hedged and the security used to construct the hedge will introduce *basis risk*: the risk that the returns on the two securities are not perfectly correlated. A hedge constructed with a related, but not identical, instrument to the one whose value is being hedged is called a *cross hedge*. If the difference between the securities is largely one of maturities, the investor may choose to construct a *weighted hedge* in which a long-dated asset or liability is hedged with short-dated positions that are rolled over. This may be necessary, for example, if the market for long-dated futures or options is illiquid.

The liquidity of the markets for hedging instruments also counts. Because hedges will almost invariably involve basis risk, it is necessary for the hedge to be continually monitored to ensure that the most appropriate instrument is being used to construct the hedge and to respond to changes in the firm's net foreign position. Since the hedge portfolio is constructed to reduce risk, it would be inappropriate to include in it securities that cannot easily be bought and sold, since illiquidity would add to the riskiness of the portfolio.

Banks, like other individual firms and investors, may need to hedge their portfolios, but they have an advantage in that many positions acquired in the course of their business entail mutually offsetting risks; these constitute a "natural" hedge. Any remaining net exposure, however, would have to be hedged using the same kinds of instruments employed by its customers: forward contracts (or more likely, swap agreements) with other banks, exchange-traded futures and options, and OTC options on foreign currency.

Dynamic Hedging

Banks' hedging strategies are complicated by the fact that many of the products they sell (e.g., caps, floors, collars, and swaps) do not have obvious exchange-traded parallels to use in a hedge portfolio; indeed, many of these products are tailor-made to fit a particular client's needs.

A bank that writes an option becomes exposed to the possibility that the option will be exercised and that it will have to buy (sell) foreign currency. The simplest hedge in this case would be to write a perfectly offsetting contract. For example, if the original exposure resulted from having written a call option, the bank could eliminate the exposure by buying a call option with the same terms, or by buying a put option and buying the underlying currency forward. For a bank that is active in the OTC

options market and maintains a large options book, many of the contracts it has written will tend to be offsetting in this way, although probably not perfectly so.

Another alternative would be for the bank to hedge its exposure by purchasing forward or futures contracts for delivery—in the amount of foreign exchange it may have to deliver. If it has written an American-style option, which can be exercised at any time prior to maturity, the bank could hedge its exposure by buying foreign currency in the spot market and holding it until the contract matures. However, this would tie up the funds for the duration of the option, and would not perfectly cover its exposure. The bank's exposure from writing an option is associated with the *possibility* of having to buy or sell foreign currency at or before a specific date in the future. It is not necessary, therefore, to hedge the total face value of the contract. To determine how much of the face value to hedge (the hedge ratio), one must find a measure of the probability that the option will be exercised.

The theory of options pricing, as originally developed by Fischer Black and Myron Scholes, and used as a guide by market participants, analyzes the relationship between the market value of an option and the price of the underlying security—in this case the exchange rate. As a currency's value increases, so does the value of an option to buy that currency at a specified price—but not by proportional amount. "Delta" is the change in the option's value associated with a one-unit change in the currency's value. Delta takes values between zero, for a deep out-of-the-money option that would never be exercised, to unity, for a deep in-the-money option that would always be exercised. Delta therefore provides a proxy for the probability that the option will be exercised, and therefore the proportion of the option's face value that must be held at any time to hedge against possible exercise of the option.

A "delta-weighted" hedge for a portfolio of currency options is constructed as follows. The bank calculates the delta for all of the contracts it has written and multiplies these by the face values of the contracts. These are then added up for each currency to reach an estimate of the expected foreign currency requirement. The hedge is then constructed using spot and forward positions in the underlying currencies.

As an example, suppose that the global position in the currency option book of a bank making a market in derivatives is short of one OTC option to deliver deutsche mark and to receive dollars (a put option). The delta-weighted hedge portfolio is constructed by finding the combination of a short position in deutsche mark loans and a long position in dollar loans, such that a portfolio with these positions and also short a put is riskless with respect to deutsche mark/dollar exchange rate movements. If the bank establishes these positions, it will have perfectly hedged its short put position.

This strategy creates a *synthetic option* in the sense that it replicates the pattern of returns to an option, generated by movements in the exchange rate, that the bank could have used to hedge its exposure. But because delta changes with the exchange rate, the interest rate differential, and the standard deviation projected for exchange rate movements, the positions must be adjusted constantly—hence the term dynamic hedging—to maintain the equivalence of the position to a put option.

Suppose that a weak currency is actively being defended at the lower bound of the ERM grid. An interesting feature of the dynamic hedging strategy for a synthetic put is that when the exchange rate is being actively defended through an increase in the interest rate, the dynamic hedging formula prescribes that the short position in that currency be made shorter still—that is, the delta or hedge ratio increases. A large rise in the interest rate aimed at imposing a squeeze on speculators will therefore cause a hedging program instantaneously to order a sale of the weak currency. If a large number of market participants implemented such programs, the effectiveness of an interest rate defense of a weak currency could be weakened.

There are other problems with dynamic hedging that diminish its effectiveness, particularly under turbulent market conditions. To be most effective, the hedge portfolio needs to be re-evaluated and adjusted continuously. However, this would increase the transactions costs to the point at which the costs of managing the portfolio outweigh its benefits. Consequently, in practice, the hedge weights are adjusted only when the weights implied by the model differ by more than an acceptable amount from the actual weights. The transactions costs of the hedge are reduced but so is its effectiveness.

The most important problems with dynamic hedging are based on more fundamental features of asset pricing. Standard option pricing formulas do not allow for the possibility of jumps in exchange rates, for example, during a realignment of ERM central parities. Thus, an out-of-the-money option has a very low delta, and would not therefore be aggressively hedged. A surprise realignment, however, could greatly increase the delta, leaving a bank underhedged. Moreover, the construction and maintenance of the hedge portfolio call for the ability to trade both the underlying asset and its derivatives continuously. If for some reason any of these markets become illiquid, the hedge breaks down.