THE DEVELOPMENT OF A TRADED IRISH POUND CURRENCY OPTIONS MARKET

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Membership of the European Monetary System (EMS) since 1979 has smoothed movements of the Irish Pound vis-a-vis other member currencies. Nevertheless, the Irish Pound continues to fluctuate against other major international currencies, particularly sterling and the US dollar. For many Irish companies therefore, exchange rate volatility may have a significant impact on profitability. Portfolio investors also hold a large pool of foreign currency assets (in excess of IR£500 million). Both trading companies and portfolio investors may therefore wish to apply strategies to manage their foreign exchange exposure. Foreign currency (FX) options provide a means of either eliminating or diversifying currency risk. This paper considers the role which a quoted foreign currency options market could play for Irish based companies and investors.

Exchange Risk Management Techniques

A recent survey [Donovan and Walsh, 1985] among both Irish owned companies and Irish based subsidiaries of multinationals indicates that these companies use a variety of strategies to cover their foreign exchange exposure. Where the exposure is trade related e.g. where there is a time delay between payments or receipts of foreign currency and the date at which a transaction is agreed, a variety of protective strategies may be employed. The most popular among companies is the use of the Irish pound/foreign currency forward markets [Donovan and Walsh, 1985]. The survey, however, indicated a desire also by companies to cover exposures other than those which are directly trade-related. An example might be a competitive tender in foreign currency for an overseas project. The outcome of the tender is not predictable and current exchange control regulations do not permit the use of the Irish pound forward markets. For companies wishing to cover their non-trade related exposures, a recently developed Irish pound/foreign currency 'hedge' market is now widely used.[1]

An alternative device is provided by some banks who are prepared to create Irish pound/foreign currency options for corporate customers. These options provide the company with a right (as opposed to an obligation) to buy or sell foreign currency, out of Irish pounds, at a specified rate at a particular time in the future. These 'over the counter' options are private contracts between the bank and customer, and are generally speaking neither quoted on an exchange nor traded during their life time.

In the UK and US, FX options markets exist where options in the major international currencies are quoted and actively traded. Marketability significantly improves the value of options as risk transfer insruments. Another benefit from market quotations is that a more objective benchmark is provided in setting the option price. It is likely that a premium is built into the pricing of over-the-counter options to reflect the inability of the writing bank to cover itself fully against adverse market movements during the life of the option. Sellers of over-the-counter options can hedge their positions through spot or forward transactions in the underlying currencies. Cover can also be provided through transactions in the Deutsche Mark traded options (i.e. using the DM as a proxy for the Irish pound). It is not possible to take cover, however, through the most direct method viz., purchasing offsetting Irish pound FX options in the market. This may be responsible for the general perception evident in the Irish market that over-the-counter options are expensively priced [Donovan and Walsh, 1985].

The development of a market in quoted Irish pounds/foreign currency options would significantly increase their use as instruments for foreign exchange risk management. In addition to trading companies, portfolio investors would, from time to time, be likely holders of these options to cover their significant foreign currency asset exposure.

Nature of Option Type Instruments

The key feature of options which distinguishes them from forward or future-type instruments is that they confer a right as opposed to an obligation. In a forward currency contract both parties are committed to a foreign exchange transaction, at some time in the future. The holder of a currency option, on the other hand has the right for a fixed period of time to buy or sell the specified currency at a fixed price. Such a holder will therefore exercise the rights enjoyed under the option only if it is economically advantageous to do so.

Terminology

A *Call Option* confers the right on the owner to buy; a *Put Option* confers

the right on the owner to sell the underlying currency. The *Exercise* or *Strike* price refers to the fixed price at which the option may be exercised. The option *premium* is the name used to describe the market price of the option. The investor who purchases an option is referred to as a *buyer;* the seller of the option is termed the *writer.* A crucial distinction is made between two forms of options, depending on whether they can be exercised at the expiration date only or at any time prior to the expiration date. The former are known as *European* options, the latter as *American* options. Generally speaking the options which are traded in the financial markets are American options.

Where the exercise price of a call option is below the current price, the option is said to be *in-the-money* (the converse definition applies to put options which are *in-the-money* when the exercise price is above the current price). Where the exercise price of a call (put) is above (below) the current price, on the other hand, the option is said to be *out-of-the money.* The *volatility* of the underlying currency is an important factor in the valuation of options. It is defined as the standard deviation of the underlying security.

Example

A diagramatic representation of the profit/loss situation of an option holder can usefully highlight some key attributes of options. Figure 1(a) represents the profit/loss situation of the (Irish pound based) holder of a sterling call option, with an exercise price of IR£1.20, and where the purchaser of the option paid a premium of IR£0.05 (5 pence) for the original option. If at the expiration of the option the sterling/Irish exchange rate is higher than IR£1.20 the holder will exercise the option. At a rate of IR£1.20 or lower, it does not make economic sense to exercise. Thus in the latter case the option holder will 'lose' the IR£0.05 pence per £ paid for the option. Between IR£1.20 and IR£1.25, the loss suffered progressively diminishes so that, above IR£1.25, the investment in the call option becomes increasingly more profitable.

This example highlights two key features of options:— (i) the holder of the option has a limited downside exposure, the maximum of which is the original investment in the option. (ii) Aside from the original cost, the holder fully participates in any favourable movement in the underlying security (in this case, any expiry exchange rate greater than IR£1.20). Figure 1 (b) illustrates the analogous situation with a sterling put option, where the premium again equals IR£0.05 per pound. At expiry, the put option (i.e. the right to sell sterling at IR£1.20) will be exercised if the rate is lower than IR£1.20 and not if the rate is IR£1.20 or greater.

Figure 1: *Pricing relationships which apply to holders of (a) call options and (b) put option.*

(a) Purchase of a Currency Call Option

(b) Purchase of a Currency Put Option
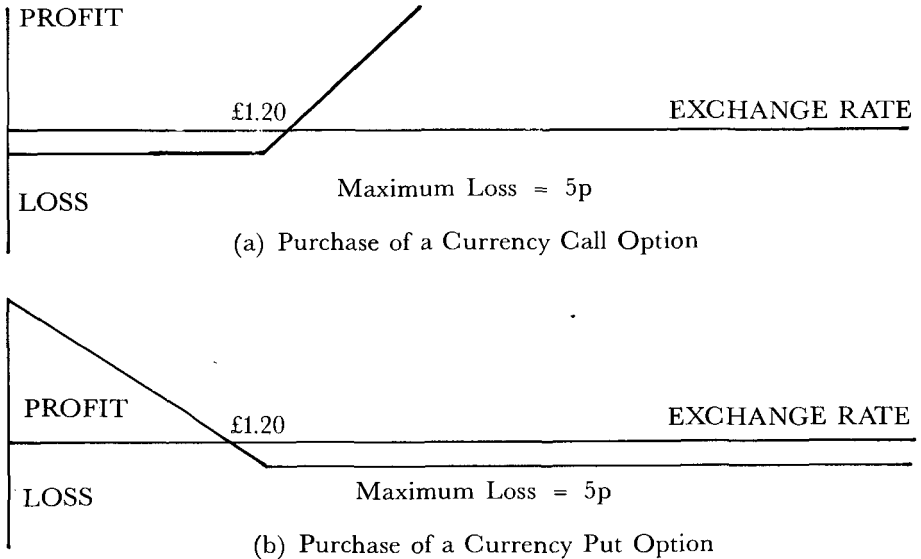
Valuation Basis of Currency Options

As with any other instruments which are traded, the prices of stock and currency options are established by market practitioners. Thus fundamental valuation approaches to options will not provide a full picture of options pricing, in rapidly changing markets. Volatility is a key variable in the valuation of options. The expectations of investors about future volatility will be an imporant input into pricing, which a fully mathematical approach cannot fully capture. A need nevertheless exists to find an appropriate fundamental basis for the valuation of options. One use of such a valuation approach might be to identify arbitrage opportunities if the options market itself is inefficient. Another might be where the options contracts are 'private' (over the counter) transactions e.g. in the case of currency options, where a bank writes an option for a customer.

In the case of stock options, the basic Black-Scholes (1973) approach, or some development thereof, is now widely accepted academicaly and by market practitioners. Call and put option values are related to five parameters, exercise price, current stock price, time to maturity, the risk-free interest rate and the volatility of the underlying security.

Currency options are a relatively recent market innovation, trading on the Philadelphia Stock Exchange only since end 1982. The valuation

framework is therefore not as well developed as in the case of stock options. The major difference between stock and currency options is that in the former, the investor faces one riskfree rate, (assumed to be constant), while in the latter, there are two riskfree rates, the domestic and foreign. Using the Black-Scholes framework, valuation formulae have been successfully developed for European FX call and put options [Garman and Kohlhagen 1982]. A similar valuation approach was developed by Grabbe (1983). The European currency call option formula for example is as follows [Garman and Kohlhagen , 1982].

Currency Call Option Formula

$$C(S,T) = e^{-R_F T} SN \left(\frac{\ln \frac{S}{X} + (R_D - R_F + (\frac{1}{2}6^2))T}{6 \sqrt{T}} \right)$$

$$- e^{-R_D T} XN \left(\frac{\ln \frac{S}{X} + (R_D - R_F - (\frac{1}{2}6^2))T}{6 \sqrt{T}} \right)$$

The Garman-Kohlhagen formula, however, does not provide for the valuation of American currency options. Early exercise of American currency options may be a factor. Intuitively, for call options, this might be expected where the options are in-the-money, and the foreign interest rate is significantly higher than the domestic. The converse would apply with put options. No theoretical model of American currency call and put options has to-date been reported in the literature.

Currency call option values thus:— decrease with increasing exercise price; increase with increasing current exchange rate; increase as the time to expiration is greater; increase as the domestic risk-free rate rises; decrease as the foreign risk free rate rises and increase with volatility of the underlying exchange rate.

Valuation of Irish Pound Currency Options

An appropriate valuation framework will be an important aspect of the development of a quoted Irish pound currency options market. A fully developed model is not available to describe quoted American currency options (i.e. currency options which can be exercised at any time up to maturity). It is likely however that a useful approximation is provided by the Garman and Kohlhagen (1982) model for European options (i.e. those which can be exercised only at maturity).

As a step towards developing a pricing approach for Irish pound currency

options, the authors considered how accurate an approximation the Garman-Kohlhagen approach provides for traded currency options and the valuation parameters likely to be of relevance in the Irish context.

Relationship between prices of American Currency Options and Garman-Kohlhagen approach

Unlike call options on non-dividend paying stock, early exercise of American FX options is a distinct possibility. In theory, this is more likely to occur with deep-in-the-money options (particularly calls on currencies with negative forward premiums and puts on currencies with positive forward premiums). It is conceivable therefore that in the market place such options would trade at a premium above their theoretical European valuation level. As a means of estimating this premium for call options, quoted market prices of currency call options in the Philadelphia Currency options exchange were compared to the theoretical value of equivalent European call options, estimated using the Garman & Kohlhagen (1982) framework. This approach was applied to analyse the sterling and DM call options quoted in Philadelphia in the period 1st January 1984 to 30th June 1984. Table 1 shows the premium values obtained and illustrates other variables estimated.

Table 1: *Regression of American/European currency option premium on (1) time and (2) exercise/stock price ratio for both DM and sterling call options.*

Currency	Premium of American over European	Time	Exercise/Stock Price Ratio
DM	19.90 (±4.08%)	0.0992 (0.5499)	0.7142 (0.5364)
Sterling	17.80 (±5.61%)	0.2852 (0.2192)	0.3412 (0.1388)

NOTES

1. In view of the assumption that stock prices are log-normal, the log-linear form of the regressions are represented.

2. Value presented above are the βeta of the regression (with R^2 in parentheses, giving the statistical level of the relationship).

The results generally confirmed that call options were valued at a premium to the theoretical European value, after Garman & Kohlhagen. For Deutsche Mark options the mean premium value was 19.90% (±4.08%), for the sterling options the equivalent figure was 17.80% (±5.61%).

The study also endeavoured to establish the factors which might influence the level of the premium. The effect of two variables in particular were studied, the effect of time and the effect to which the option was in or out of the money.

Intuitively, time would appear to be a factor likely to affect premium levels i.e. on the basis that the ability to exercise early is more valuable the longer the period to option expiry. Intuitively, also, a higher value might be expected to be paid for the ability to exercise early where the option is in-the-money (since an option out-of-the-money is valueless if exercised early).

The ratio of exercise price to stock price is a measure of the extent to which a stock is in or out-of-the-money. Thus for call options where the ratio is:— $<$ 0, the option is in-the-money; $=$ 0, the option is at-the-money and $>$ 0, the option is out-of-the-money.

The level of the American/European premium (dependent variable) was therefore regressed on (i) time to maturity and (ii) the exercise/stock price ratio (independent variables). For both DM and sterling options, these factors were found to influence the premium levels. Table 1 shows the results obtained, when the American/European premium was regressed on time and the exercise/stock price ratio. Similar relationships were found in each case with both time and the exercise/stock price ratio positively influencing the level of the premium. In the case of time, the strengths of the relationships are surprisingly low, particularly in the case of Deutsche Mark options.

The effect of the exercise/stock price ratio is counter-intuitive, as it indicates that as the option goes increasingly out-of-the-money (i.e. as the exercise/stock price ratio increases) the level of the premium increases. Since early exercise of an out-of-the-money option is unlikely (because it is worthless), this effect is difficult to rationalize on economic grounds. However similar effects were noted by Black (1975) and Merton (1976), who observed that out-of-the-money stock call options are priced above the Black-Scholes valuation prices. It has been suggested that 'conservative' purchasers of out-of-the-money options are paying a premium to the writers (sellers) of these options (Black, 1975).

In general terms, the results of the empirical study indicate that currency call options are being traded at a premium above the Garman-Kohlhagen valuation basis. Futhermore weak relationships appear to exist between the premium levels and the two variables analysed.

Valuation parameters for Irish Pound currency options

It is suggested that the valuation approach should be generally based on the Garman and Kohlhagen (1982) model plus a premium to reflect the ability to exercise early. Thus the following parameters will be required:— (i) Current (spot) exchange rate (Irish pound/foreign currency); (ii) Exercise exchange rate (Irish pound/foreign currency); (iii) Time to option maturity; (iv) Current Irish risk-free rate; (v) Current foreign risk-free rate; (vi) The premium of the American option over the European option; (vii) Volatility (i.e. instantaneous variance) of the Irish pound/foreign currency exchange rate.

Items (i) and (iii) above will be unambiguous. For (iv) and (v) the 3 month Exchequer Bill Rate and the equivalent for the foreign currency are suggested. Market forces should over time establish the size of the premium (vi) at which the American option should be valued vis-a-vis the equivalent European option. As a starting point, however, it is suggested that a premium of 15-20% should be added to the Garman and Kohlhagen valuation.

The question of the appropriate measure of the instantaneous variance of the exchange rate (item (vii)) is a more problematic issue. It is not possible
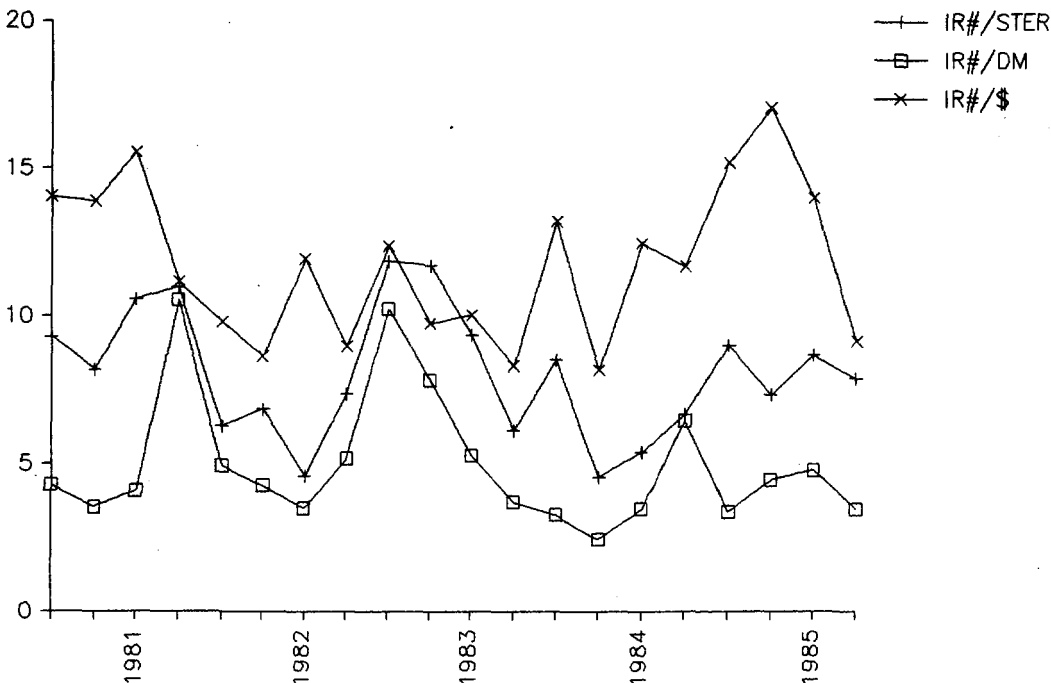
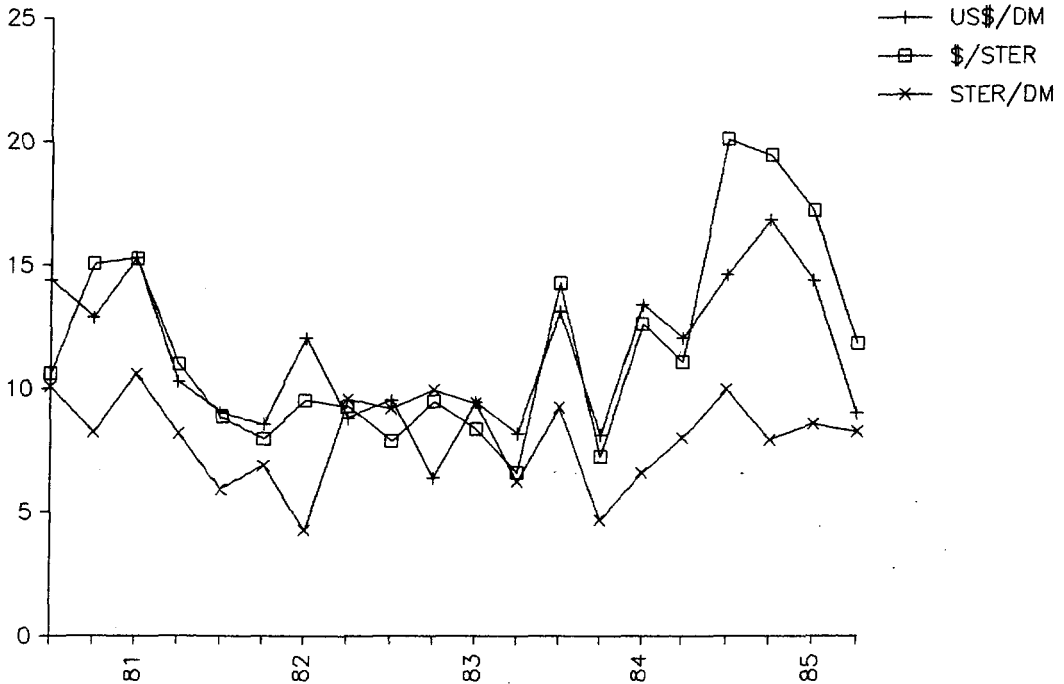*Figure 2:* **VOLATILITY OF IRISH POUND**

Figure 3: VOLATILITY OF MAJOR CURRENCIES

to calculate the instantaneous variance itself so an effective proxy must be identified. The more feasible proxy measures would appear to be:— (i) a measure of the historic variance of the exchange rate, particularly the most recent experience; (ii) an estimation (based on economic forecasts) of future variance and (iii) an estimate of the volatility implied in current option prices (this implies that an options market already exists).

On balance option (i) above is favoured. Whatever the efficiency implications in a method based on using ex-post data as a measure for a future estimate, it provides the most effective measure, particularly when an options market is being newly developed.

The authors estimated the volatility of the Irish pound exchange rate against sterling, dollar and the Deutsche Mark over the 5 year period commencing January 1981 (Figure 2). The volatilities of the cross currency rates between sterling, dollar and the Deutsche Mark were also measured (Figure 3). Volatility (expressed as % standard deviation) was measured over consecutive 91 day periods and annualised. The following indicates the range of values obtained.

	Volatility Range
IR£/Sterling	4.6 – 11.9%
IR£/Dollar	8.1 – 17.2%
IR£/Deutsche Mark	2.4 – 10.3%
Dollar/Sterling	6.6 – 20.1%
Dollar/Deutsche Mark	6.4 – 16.9%
Sterling/Deutsche Mark	4.2 – 10.6%

The data confirm the beneficial effects of EMS membership in reducing the volatility of the Irish pound versus its EMS partners. Foreign Exchange options on these EMS currencies are unlikely to be of major interest but would, if required, carry lower values than equivalent ones to sterling and the U.S. dollar. No particular trends over time are evident in respect of the Irish pound/sterling and Irish pound/dollar volatility levels. (They do not, however, confirm a particular upward trend over time which is a perception of some market participants). A general lack of stability in the volatility measures should be reflected in variability in option prices over particular periods of the market. The volatilities of the cross currency rates between sterling, dollar and Deutsche Marks indicate similar patterns to those of the Irish rates.

What information do the above volatility trends provide about the likely pricing patterns of Irish pound traded currency options? For at-the-money options there is effectively a linear relationship betwen option values and volatility. Based on Figure 2 therefore one can assume that currency option values would vary significantly over time and for different currencies.

Figure 4 represents this graphically.[2] Currency option values reflect the effect of six known parameters (plus a premium for the ability to exercise early) at any point in time. Figure 4 calculates the values of three-month at-the-money call options (expressed as % of exercise price) at different implied values of the other parameters. The option values are graphed against the % forward premium of the foreign currency (which reflects both the domestic and foreign interest rates) at different volatility levels. The influence of volatility is emphasised by the upward shifts of the currency, as volatility is increased.

The vertical bar diagrams of Figure 4 represent the range of Irish pound at-the-money call options (expressed as % of exercise price) at different Irish pound. The equivalent figures for dollar-priced options into sterling and the Deutsche Mark are also provided.
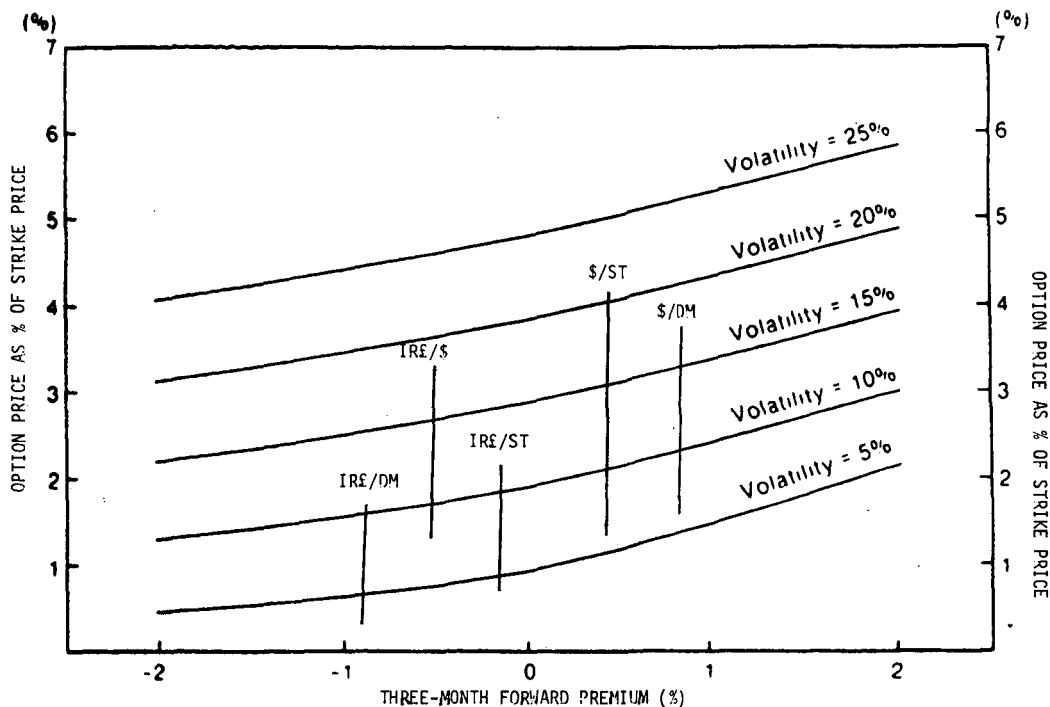
Figure 4: *Pricing of currency call options at different volatility levels. (Vertical bar lines represent Irish pound currency options).*

To price the values of quoted Irish pound options, two factors in addition to those of Figure 4 would be reflected (a) the discount or premium of the exercise price relative to the spot price (i.e. the extent to which the option is in or out-of-the-money) and (b) a premium for the ability to exercise early. Nevertheless Figure 4 would indicate the following likely trends in Irish pound options pricing.

(i)   At any point in time, the options premium for different currencies may differ.

(ii)   Options on EMS currencies are likely to cost significantly less than equivalent options on non-EMS currencies.

(iii)   There is no fundamental reason why traded options priced in Irish pounds into other world currencies (outside the EMS) should in general terms differ in price from options into the same currencies priced in US dollars.

The above comments reflect of course the historical experience of volatility. Pricing of future Irish pound currency options will reflect future experience and expectations of volatility.

Structure of an Irish Pound Currency Options Market

A formalised structure will be necessary to ensure that a currency options market will operate effectively. An essential element will be some form of options clearing company which will provide a framework whereby market practitioners rely on the name of the company rather than on the credit standing of particular writers or buyers of options. Thus the functions of the options clearing company will include: (i) carrying out credit assessment of authorised market practitioners, (ii) setting margin requirements for market participants (this margin requirement will operate for writers of options to ensure that they are continually in a position to meet exercise needs in relation to the option), (iii) controls to ensure that operators, both writers and buyers, do not get over-exposed in particular option positions and (iv) a trading 'environment' of some kind for options will be required. In the major world options markets, trading pits operating on an open-outcry basis exist for currency options trading. It is questionable whether a physical trading floor could be fully utilised in the Irish context or would be the most desirable.

A further factor is that options on Irish short-term interest rates or long-term gilt-edged stocks are not now either quoted or traded. It could be that an options clearing company could take on a role for all of these option instruments.

Summary and Conclusions

This paper suggest that a traded market in Irish pound foreign currency options would be an important addition to the risk management techniques available to Irish based holders of foreign assets. It is believed that trading companies and portfolio investors are likely to use such a market.

An empirical study of the pricing pattern of existing currency options (quoted in Philadelphia) indicates that a variation of the Black and Scholes model (after Garman and Kohlhagen 1982) provides a suitable valuation framework. The options were found to carry a premium relative to the model, however, reflecting the fact that early exercise may occur. The study indicates that two factors, time to maturity and the exercise/stock price ratio may affect the premium level.

Volatility is a key input into options valuation. Using daily closing rates, the volatility of the Irish pound rate against sterling, the Deutsche Mark and the dollar, over the five year period (1981-1985) was measured. Two principal conclusions emerged from this analysis. (1) Volatility of the Irish pound/Deutsche Mark exchange rate was significantly lower, and more

stable than that observed with sterling and the dollar — clearly a benefit of EMS membership. (2) The volatility of the Irish pound against sterling and the dollar fluctuates over time. No basis was however found for a perception evident among some practitioners in the Irish foreign exchange market that volatility has been increasing over time.

The impact of these volatility trends on options pricing was discussed. Because of the significant impact of volatility on value, the trends in volatility in the underlying currencies are likely to be reflected in options prices. Overall however, it can be stated that the premium levels of Irish pound options into EMS currencies will be lower (reflecting reduced volatilities against these currencies) but that with this exception, the general levels of Irish pound priced options into foreign currencies should not differ from equivalent dollar or sterling priced options. Finally, the paper considers the possible organisational structure of a traded Irish pound currency options market. Some form of options clearing company which might also handle other forms of options is suggested.

NOTES

1. *In this hedge market (usually between a bank and a corporate customer) no foreign exchange transactions occurs. The bank strikes a rate with the company for say three months hence (an example might be a quote of $1.00 per IR£1). If in three months time, the rate is $1.10 per IR£1, the customer will pay the bank the Irish pound equivalent of $0.10 (IR£0.09) per IR£ of the transaction. Thus settlements in these transactions are in Irish Pounds.*

2. *The discussions in the rest of this section (and Figure 4) reflect trends in European options, where precise mathematical relationships can be drawn. The trends will be very similar for American options.*

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