INDICATORS OF SHORT-TERM INTEREST RATE EXPECTATIONS. THE INFORMATION CONTAINED IN THE OPTIONS MARKET

María Cruz Manzano
and Isabel Sánchez

Banco de España - Servicio de Estudios
Documento de Trabajo nº 9816

INDICATORS OF SHORT-TERM INTEREST RATE EXPECTATIONS. THE INFORMATION CONTAINED IN THE OPTIONS MARKET(*)

María Cruz Manzano
and Isabel Sánchez

(*) We should like to thank Montserrat Jiménez of the Statistics Office for her assistance in preparing the data base. This paper has also benefited from the comments of the participants in preliminary discussions on the project and, especially, from those made by Roberto Blanco in the Internal Research Department Seminar at which this paper was presented.

Banco de España - Servicio de Estudios
Documento de Trabajo nº 9816

In publishing this series the Banco de España seeks to disseminate studies of interest that will help acquaint readers better with the Spanish economy.

The analyses, opinions and findings of these papers represent the views of their authors; they are not necessarily those of the Banco de España.

The Banco de España is disseminating some of its principal reports via INTERNET and INFOVÍA.

The respective WWW server addresses are: http://www.bde.es and http://www.bde.inf.

ISSN: 0213-2710
ISBN: 84-7793-640-4
Depósito legal: M. 44001-1998
Imprenta del Banco de España

ABSTRACT

The usual indicators of expected interest rates -forward rates obtained from the zero-coupon curve or futures market rates- only approximate agents' mean expectations of future rates. These mean expectations give no indication of the distribution of the probabilities agents attach to the possible levels of interest rates for a particular term at a particular horizon.

Estimating the probability function of expected rates provides indicators which help to assess the effects of monetary and financial shocks. This estimation can be carried out using information obtained from the interest-rate options market.

This paper has estimated, using a non-parametric method, the distribution function of expected three-month interbank rates, using data on call options on the MIBOR-90 future. The evolution over time of this distribution function has enabled the effects of movements in the Banco de España intervention rates on the distribution of agents' short-run interest rate expectations to be assessed.

CONTENTS

I. INTRODUCTION

The interest rates expected by economic agents are the product of various factors: the behaviour of the equilibrium real interest rate which equates flows of saving and investment in the economy, inflation-rate expectations and the risk premiums incorporated at the different terms. The relative importance of these factors depends on structural factors -e.g. the preferences of economic agents- and the period to which such expectations relate[1].

The path of expected rates provides, under certain assumptions as to the behaviour of real interest rates, estimates of the path of inflation expectations and/or changes in agents risk premiums. Numerous examples of this use can be found in the reports of financial analysts and many central banks.

Agents' expectations are not observable and, therefore, it is necessary to use indicators or proxies thereof. In the case of expected interest rates, the yield curve -zero-coupon curve- and rates in forward markets -"Forward Rate Agreements"[2] and futures[3] are the indicators normally used. In fact, it can be demonstrated that the implicit rates (forward rates) obtained from the zero-coupon curve are a good approximation to expected rates, depending on the behaviour of the liquidity premiums. If the premiums are not significant or, at least, relatively stable, forward rates are a good approximation of expected rates or of changes in expected rates.

---

[1] In this respect, there is evidence that inflation expectations are a more important determinant of long-term than short-term nominal rates. See, for example, for the Spanish case, Manzano and Campoy (1997) and Alonso et al. (1997).

[2] See, on the FRAs market and the rates negotiated, Diaz del Hoyo y Prado (1994).

[3] On the differences between these two markets see, for the Spanish case, Núñez (1992).

The indicators mentioned only give information on point values of the expected rates, namely their mean values. However, agents, when revealing their expectations, are really attaching probabilities to the possible values of interest rates, and, on the basis of these, the mean expectation is determined. Accordingly, the expected rates are stochastic variables which, as such, have a certain probability distribution associated with them.

The characteristics of the distribution of interest-rate expectations and its evolution over time are an important source of information. For example, knowledge of this distribution would give information on the degree of uncertainty with which agents view the future path of interest rates at different terms. In turn, monitoring changes in this distribution would yield information on how certain events in the financial markets -e.g. changes in monetary policy signals, sharp stock-market corrections, shocks in foreign exchange markets, etc.- affect the probabilities assigned to particular values of short- and long-term interest rates, the degree of dispersion of the expectations and the existence of skewness.

From the viewpoint of the design and conduct of monetary policy, analysis of the characteristics of the distributions of expected interest rates is useful for various reasons -see Deutsche Bundesbank, Neuhaus (1995); Bank of England, Bahra (1996, 1997); Banque de France, Jondeau et Rockinger (1997) and Banco de Portugal, Adao et al. (1997)-:

a) Agents' spending decisions are affected by changes in the probability they attach to extreme values in the distribution of future interest rates.

b) It is possible to extract from the probability distribution of expected rates information on the macroeconomic scenarios agents consider most plausible.

c) The credibility of the monetary authorities can be analysed by comparing, over time, agents' probability distribution with the interest rates compatible with inflation targets.

d) The probabilities attached by the market to the possible values of interest rates in the near future provide information on the probabilities which agents attach to different monetary policy actions. These probabilities are important to assess the effect of a particular movement in the intervention rates of the monetary authorities.

e) Increases in the probabilities assigned to the most extreme values of the distribution of expected rates, without noticeable changes in the mean expectations, indicate an increase in market uncertainty which may involve greater interest rate volatility.

It is useful, therefore, to have information on the distribution of expectations of interest rates rather than just on mean expectations. Interest-rate options contain information on this distribution. As we know, an option is a contract giving the holder the right to purchase (call option), or sell (put option) an underlying asset at a particular price (strike price), at a certain date (European option), or during the period from its purchase until its expiry (American option). For a particular underlying asset and a certain maturity, different strike prices are traded in the market, for which different premiums are paid. The relation between the different strike prices and the corresponding premiums is a function of the probability which agents attach to the possibility of obtaining a profit. The latter depends on the strike price specified in the contract and how the price of the underlying asset is expected to move during the life of the contract.

The object of this paper is to analyse, in the Spanish case, whether options on short-term interest rates contain any useful information for characterising the distribution of expectations of short-term interest rates. Section 2 gives a brief description of the Spanish options market, with special focus on interest-rate options. Section 3 analyses how information can be obtained from the relationship between the strike prices contained in options contracts and the related premiums on the probability distribution assigned by agents to the possible values of interest rates at a certain term. Section 4 applies this method to the case of options on the MIBOR-90, characterising the distribution of agents' expectations of three-month interest rates on particular dates. Finally, section 5 offers a summary and the main conclusions of the analysis.

2. MAIN CHARACTERISTICS OF THE SPANISH OPTIONS MARKET

The official Spanish financial derivatives market came into being in late 1990 with the creation of MEFF. This company is responsible both for the trading and the clearing and settlement of futures and options in Spain. The market has grown exponentially since then, to become the fourth largest European market by trading volume, although it is significantly smaller than the main international markets. Thus, for example, the number of contracts traded on MEFF is only about 15% of those traded at LIFFE.

After certain ups and downs and the suspension of trading of certain contracts due to the absence of trading, the assets currently traded on MEFF are: futures on equities (IBEX-35), futures on interest rates (MIBOR-90, MIBOR-360, and 3-, 5- and 10-year notional bonds and, since 1996, on the price differential in futures contracts on long-term bonds between Spain and Germany, France and Italy); options[4] on equities (IBEX-35 and main shares) and options on interest rates (futures on the MIBOR-90 and on 3-, 5- and 10-year notional bonds).

It should be pointed out that MEFF, as in the case of other derivative markets, obliges market members, through its Clearing House, to make an initial security deposit of PTA 20 million. It also imposes a system of margining and settlement of losses and gains arising on open positions in futures and options, to be complied with on a daily basis (see MEFF Regulations).

From the outset, futures trading has been more important than options trading. In 1996, 49 million futures contracts and 12 million options contracts were traded. At the same time, both in futures and options, the volume of interest-rate trading is higher than that of equity, although, in

[4] All the options traded on MEFF are American options, i.e. they can be exercised at any time between their purchase and their maturity.

the latter case, the number of contracts is greater. As for interest-rate options, which in terms of the number of contracts account for around 40% of all options, those on the notional 10-year bond future and on the MIBOR-90 future are the most traded. Until 1996, the volume of trading in options on the 10-year bond was greater than that in options on the MIBOR-90 future, the situation being reversed in 1997 (see Chart 1). Yet, throughout the period, the level of open positions in options on the MIBOR-90 has been higher than that in options on the 10-year notional bond. This is probably because, in the case of the option on the 10-year bond, agents close out their positions more frequently, which leads to a bigger difference between the volume of trading and the change in the open position[5].

Focusing on interest-rate options, it should be pointed out (see Chart 2) that trading in options represents between 10% and 20% of the contracts in the underlying asset (interest-rate futures). This proportion has remained very stable since 1993.

Since this paper is going to analyse the information supplied by options on the MIBOR-90, it is worth describing the main features of this contract:

- The underlying asset is the futures contract on the MIBOR-90. The nominal value of the contract was, until June 1995, PTA 10 million. Since then it has been PTA 100 million.

- The option is of the American type, i.e. the buyer may exercise it at any time until it expires.

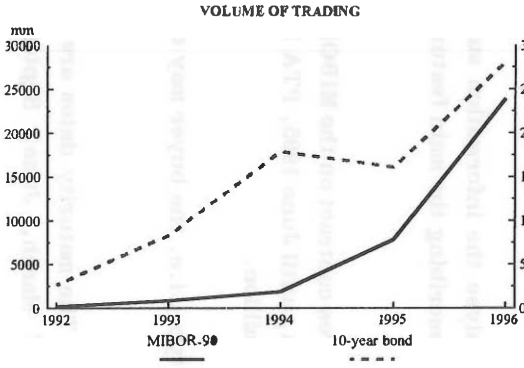
- Four maturities may be traded. The maturity dates are the third Wednesdays of the months of March, June, September and

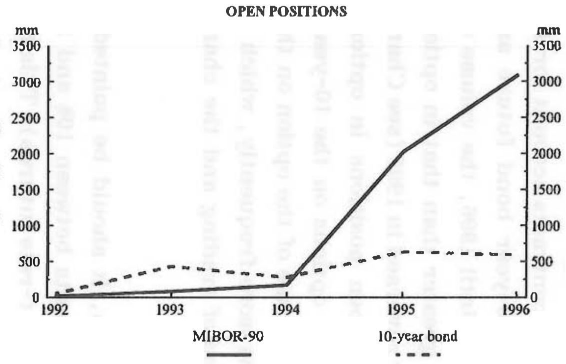
[5] On any trading day, the increase in the open position is the same as the amount of the transactions entered into, unless the market member trading with MEFF (which always acts as counterparty) merely takes out a transaction which offsets a previous transaction.

INTEREST-RATE OPTIONS

Chart 1

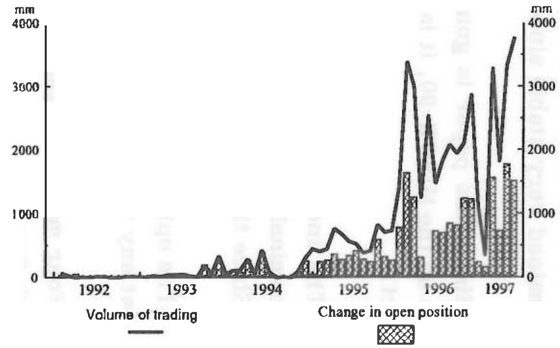
VOLUME OF TRADING AND OPEN POSITIONS



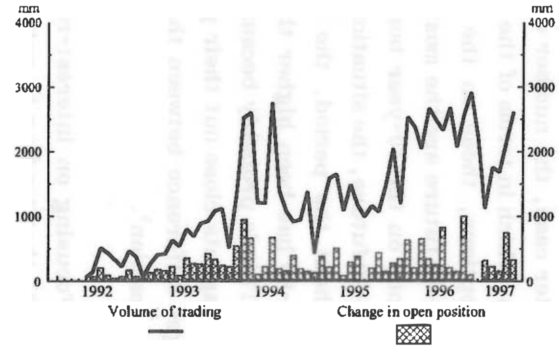


VOLUME OF TRADING AND CHANGE IN OPEN POSITIONS

MIBOR-90 (a)



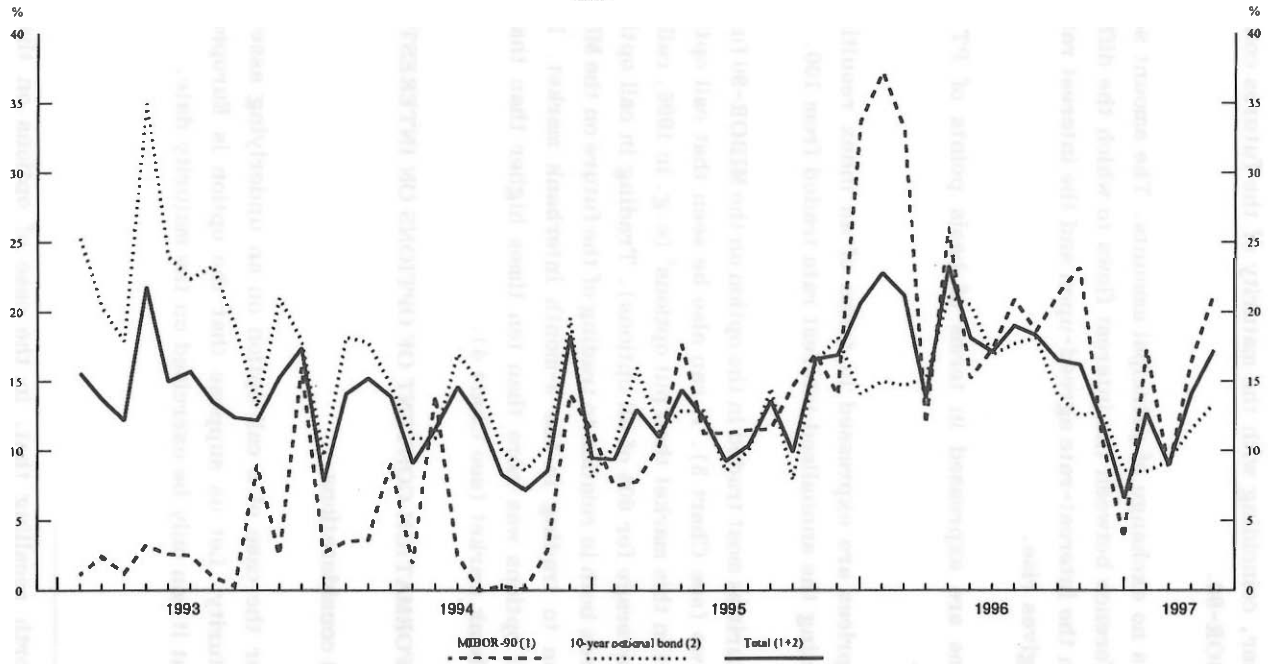
10-YEAR BOND (a)



(a) The change in open position takes no account of the reduction due to expiry of options.

Chart 2

INTEREST-RATE OPTIONS VOLUME
AS A PERCENTAGE OF UNDERLYING ASSET VOLUMES



December, coinciding with the maturity of the futures contract on the MIBOR-90.

- There is no exchange of principal amounts. The amount settled is the difference between the interest flows to which the differential between the interest-rate agreed-upon and the interest rate of the future gives rise.

- Premiums are expressed in terms of basis points of PTA 2,500 (ticks).

- Strike prices are expressed in terms of an index resulting from subtracting the annualised interest rate traded from 100.

The maturities most traded in the option on the MIBOR-90 future are the shortest two (see Chart 3). It can also be seen that call options are more important in this market than put options[6] (e.g. in 1996, call options accounted on average for 60% of all options). Trading in call options has trended upwards both in relation to trading of the future on the MIBOR-90 and in relation to trading in the 3-month interbank market. In 1997, trading in call options was more than ten times higher than that in the 3-month interbank market (see Chart 4).

3. THE INFORMATION CONTENT OF OPTIONS ON INTEREST RATES

3.1. General considerations

Consider the case of a call option on an underlying asset with a particular maturity. Let us suppose that the option is European and, therefore, that it can only be exercised on the maturity date.

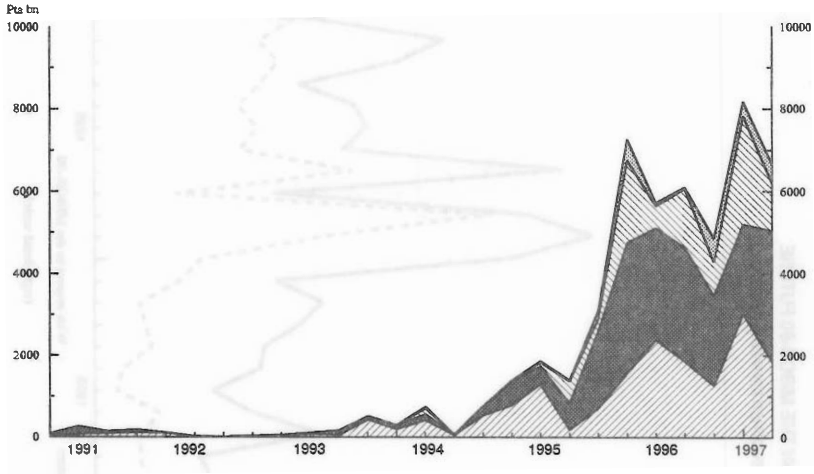
---

[6] It is worth recalling that, in the case of options on the future MIBOR-90, what is being traded is the agreement to lend (call option) or to borrow (put option) a notional interbank deposit, to be made on the date of maturity of the contract at the interest rate specified in the contract.

Chart 3

TRADING IN THE MIBOR-90 OPTION BY MATURITIES

ABSOLUTE VOLUMES



RELATIVE IMPORTANCE OF EACH MATURITY

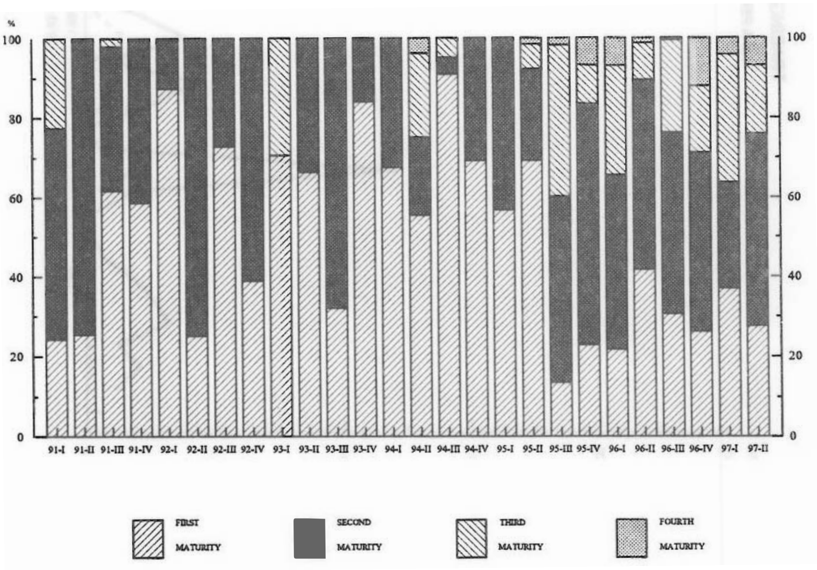
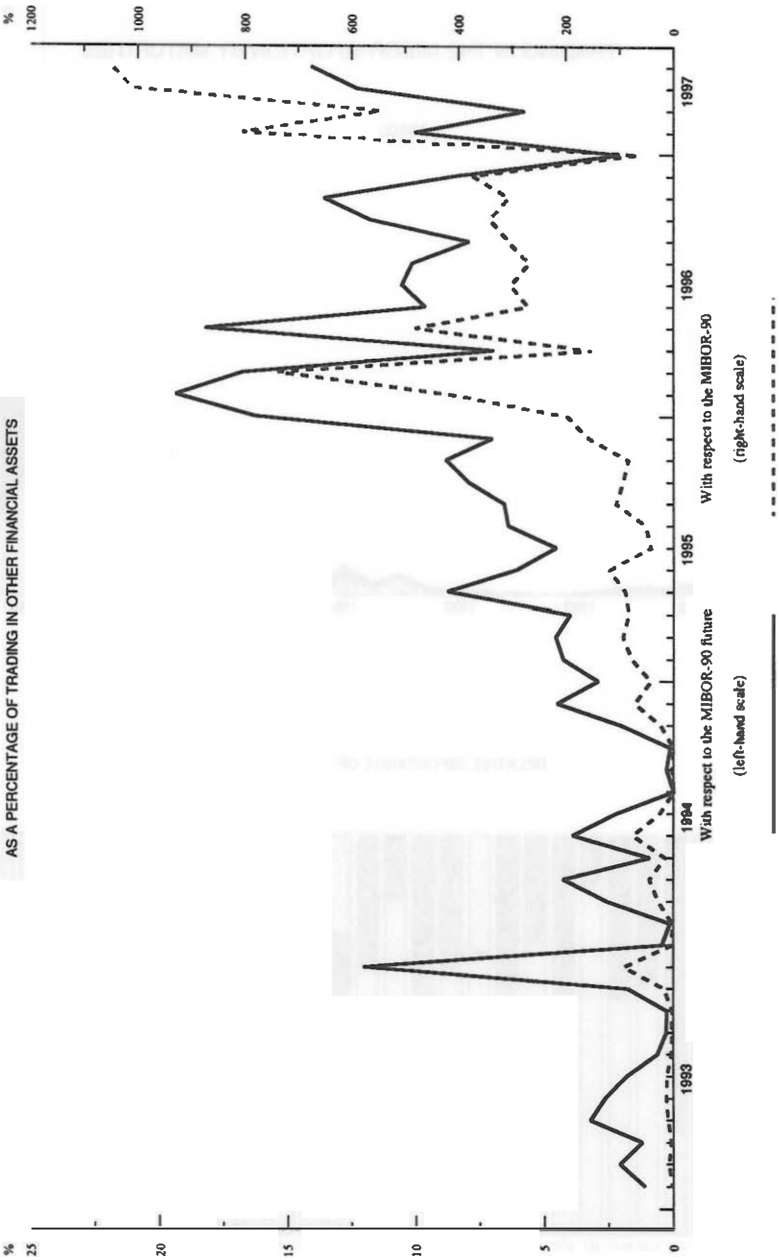


Chart 4

TRADING IN CALL OPTIONS ON THE MIBOR-90 FUTURE

AS A PERCENTAGE OF TRADING IN OTHER FINANCIAL ASSETS



For a single underlying asset and a particular maturity, there are contracts in the market with various strike prices and different premiums. In the case of a call option, *ceteris paribus*, the lower the strike price the greater the potential gain if the option is exercised, so that the price of the option (the premium) tends to be higher. This relationship between the strike price and premium will also depend on the degree of risk aversion of the agents and the probability agents attach to the possibility of the strike price being below the spot price of the underlying asset on the maturity date. Accordingly, from the relationship between premiums and strike prices for a particular underlying asset and a certain maturity date, it is possible to obtain information on the probabilities agents attach to different outcomes for the price of the underlying asset on the maturity date of the option.

The premium of an option depends on various factors: the current price of the underlying asset, the time-to-maturity, the volatility of the price of the underlying asset, the risk-free rate of interest, the expected dividends on the underlying asset during the life of the option. Its value may easily be deduced using the binomial method on the assumption that there are no arbitrage possibilities in markets -see, e.g. Gemmill (1993)-. This method is based on a risk-free portfolio, consisting of an option and the underlying asset, which is constructed to ensure that its yield is equal to the rate of interest on a risk-free asset. The theoretical value of the option deduced from this portfolio is independent of the degree of agents' risk aversion. This simple valuation method shows how it is possible to calculate the value of an option without needing to know the probabilities assigned by agents to the prices of the underlying asset at the time of maturity of the option -see e.g. Hull (1991) and Gemmill (1993)-.

Now, **with risk-neutral agents**, it can be shown that the value of the option is equal to the present value of the expected future profits, which will depend on the probabilities assigned by agents to the range of possible prices on the maturity date of the option. Accordingly, **just on the assumption of risk-neutral agents**, it is possible to derive from option prices the characteristics of the probability distribution of the prices of the underlying asset on the maturity date of the option. On this assumption, options on interest rates provide information on the probabilities which agents attach to different levels of interest rates at the maturity date of the option -see, for example, Neuhaus (1995) and Bahra (1996, 1997)-. This information may be obtained using parametric and non-parametric methods:

Parametric methods

a) Formulating hypotheses on the characteristics of the stochastic process which determines the course of interest rates, a rule for the determination of the premiums is obtained. From the latter the distribution function of interest-rate expectations is estimated.

b) On the basis of assumptions as to the distribution of probabilities assigned by agents (for example, whether or not the distribution is normal, whether two modal values are possible...), the values characterising such distribution are estimated from the observed data on strike prices and premiums. For this purpose, the difference between the values of the premiums to which such distributions would give rise and the premiums actually observed is minimised -see, for example, Bank of England, Bahra (1996)-.

Non-parametric methods

c) The characteristics of the distribution function of agents' expectations on interest rates are determined from the relationship observed between the prices of call options and the different strike prices, without any a priori assumption as to this relationship -see Breeden and Litzenberger (1978) and Neuhaus (1995)-.

The main problem with non-parametric methods is that, as will be seen below, there are not always enough strike prices available for a particular maturity to permit adequate characterisation of the expectations density function.

In view of the lack of a priori information on distributions of interest-rate expectations in Spain a non-parametric method has been selected for this paper.

3.2. Analysis of the content of interest-rate options: a non-parametric approximation

Consider a European call option on an interest-rate future, where the agents in the market in which the option is traded are risk-neutral. Assuming that all agents assign the same probabilities to the various possible prices of the underlying asset at the maturity of the option (see Annex 1), the value of the option will always be equal to the present value of the expected stream of receipts. This value (C) can be expressed as a function of: 1) the probabilities assigned to the prices of the underlying asset on the maturity date ($P(F_T)$); 2) the differentials between such prices and the strike price stipulated in the option contract (E), and 3) the risk-free rate of interest (r), such that:

$$C = e^{-r(T-t)} \int_{-\infty}^{\infty} P(F_T) \, MAX\left[F_T - E\right] dF_T \qquad [1]$$

(T-t) being the time-to-maturity of the option.

As indicated above, for a single underlying asset with a particular maturity date, contracts are traded in the market with different strike prices and, therefore, different premiums. Consequently, it is possible to analyse how the premium (C) changes as the strike price (E) changes, calculating the partial derivative of C with respect to E in equation (1):

$$C_E = -e^{-r(T-t)} \int_{E}^{\infty} P\left(F_T\right) dF_T \qquad [2]$$

As can be seen, expression (2) is related to the value of the distribution function of the price of the underlying asset when this price coincides with the strike price, multiplied by the discount factor. That is:

$$D(E) = 1 + e^{r(T-t)} C_E \qquad [3]$$

D (E) being the value of the distribution function for $F_T = E$.

From this relationship it is possible to calculate the probability that the price of the underlying asset (F_T) will lie between two consecutive values of the strike price, as follows:

$$\text{Prob}\left(E \leq F_T < E + \Delta E\right) = \left(D\left(E + \Delta E\right) - D\left(E\right)\right) \qquad [4]$$

Combining equations (3) and (4) yields:

$$\text{Prob}\left(E \leq F_T < E + \Delta E\right) = \left(C_{E + \Delta E} - C_E\right) e^{r(T-t)} \qquad [5]$$

Given that there is only a discrete number of strike prices and premiums in the market, it is not possible to estimate directly function C above, which is a continuous function. Accordingly, the calculation of the density function which appears in equation [1] is very imprecise. However, the estimation of the probability that the price will lie within particular intervals, although less ambitious, is subject to a small approximation error -see Neuhaus (1995)-.

In fact, using a Taylor expansion to approximate the derivative of function C when the price of the underlying asset is equal to the strike price, the probability that the price of the underlying asset lies between two consecutive strike prices is:

$$\text{Prob}\left(E \leq F_T < E + \Delta E\right) = \frac{[C(E+2\Delta E) - C(E+\Delta E)] - [C(E) - C(E-\Delta E)]}{2\Delta E} e^{r(T-t)} \qquad [6]$$

Equation (6) shows how the probabilities which the buyer of a call option assigns to the possibility that the price of the underlying asset -here, the three-month rate of interest- will lie within a certain interval can be approximated linearly[7]. The only information necessary to make this approximation is the premiums corresponding to the various strike prices.

---

[7] There are non-linear methods which enable these relationships to be approximated using polynomials of order n. These methods generally offer less satisfactory results than those obtained with linear methods -see, for example, Jondeau et al. (1997)-.

The probabilities estimated in accordance with this method have two desirable properties when a distribution function is characterised:

1. They are always positive, since the absence of arbitrage ensures that the relationship between the premium of the option and the strike price is going to be negative and convex.

2. If there is a sufficient number of exchange-traded strike prices, the sum of the probabilities calculated for a particular maturity will be equal to one[8]. This is because the first derivative of the premium with respect to the strike price is the probability that the expected price is greater than or equal to the price considered -see Neuhaus (1995)-.

If agents are risk-neutral, the expected value of the rate of interest on the maturity date of the future, calculated using the density function of expected rates, must always be equal to the price of the future with the maturity date considered. If the approximation carried out is sufficiently precise, this property must obtain.

The validity of the non-parametric method essentially depends on the number of exchange-traded strike prices for each maturity and the quality of the valuations of the various contracts. Given the approximation method used, if the number of strike prices is not sufficiently large, the tails of the probability distributions are not going to be satisfactorily characterised. However, with this method, the lost mass of probability which corresponds to the tails of the distribution is known at all times. The attachment of this probability to each of the tails is only possible if: 1) the probability that the price is greater than the lowest observed strike price (lower tail) is equal to one, in which case the lost probability

---

[8] The greater the number of exchange-traded contracts, for each maturity date, the better valued will be the contracts corresponding to the most extreme values of the strike price and, therefore, the premia corresponding to these extremes will tend to coincide with their intrinsic values. If the premia do coincide with their intrinsic values it can be demonstrated that the sum of probabilities calculated for the various interest-rate intervals is equal to one.

necessarily corresponds to the upper tail, or 2) the probability of the price being greater than the highest observed strike price (upper tail) is equal to zero. In all other cases, the observed strike prices are not sufficient to adequately characterise the tails of the distribution.

If the premiums corresponding to each strike price are inappropriate, i.e. if the contracts are not well valued, it is obvious that the probabilities calculated are not a good approximation to the theoretical probabilities attached. This problem may arise if information on the premiums is obtained at different times during a session.

The implicit probabilities are calculated on the basis of the hypothesis of risk-neutral agents. If agents were risk-averse, then the probabilities would be biased estimations of the actual probabilities assigned by agents, owing to contamination by the risk premiums incorporated.

4. AN APPLICATION: THE INFORMATION CONTENT OF OPTIONS ON THE MIBOR-90 FUTURE

4.1 The set of information used

Expected short-term rates of interest are a relevant indicator for monetary policy both for the purposes of its design and when assessing the effects of its application. They help to assess the desirability of market intervention, by offering information on the monetary conditions in the economy and on agents' perception thereof and they are also indicators of how the actions of the central bank affect market sentiment. The foregoing gives an idea of the importance of analysis of the distribution of expectations of short-term rates of interest. This paper uses information supplied by options on the MIBOR-90 to characterise the distribution.

As in the case of all options, for the underlying asset in question (a notional interbank deposit) and for each maturity there are several exchange-traded strike prices. These prices are quoted by MEFF in accordance with the terms of its regulations, at the request of market members. In 1997 the average daily number of exchange-traded strike prices was around thirty.

It should be pointed out that, for each maturity, agents have open positions in contracts with strike prices which are not necessarily traded every day. In fact, often, only the contract corresponding to a single strike price is traded. However, as there are positions for the different exchange-traded strike prices, and the system of margins established by MEFF obliges open positions to be valued daily, all live options are valued at the close of trading, enabling the Clearing House to settle losses and gains daily.

Until September 1996, MEFF used the volatility of the option at the money to value all open contracts, whatever their strike price or maturity, applying the Black-76 formula (a model for valuing European options on futures). This meant that the Black model was used regardless of whether or not its assumptions were fulfilled. From that date, coinciding with the significant increase in options trading, this valuation system was improved with the creation of the so-called volatility club, consisting of eight market members who quote volatilities for each strike price and each maturity daily at the close of trading -see MEFF (1997)-. When the volatilities quoted by each of the eight members have been obtained, the harmonic mean is calculated for each strike price/maturity, so that if there are extreme values they do not significantly distort the mean. The Black-76 formula is applied to the volatility curve (volatility smile) so calculated, to give a valuation of all live contracts whether or not they are traded[9] -see MEFF (1997)-.

It is worth pointing out that the valuation system used by MEFF since September 1996, unlike the previous one, does not impose the Black formula or, therefore, the assumptions which underlie this model.

---

[9] Meff adjusts for the fact that the Black-76 formula refers to European options, while the options being valued here are American. Options are valued choosing the maximum of the valuation obtained by applying the Black formula and the intrinsic value. This method can be considered to approximate well the valuation which would be obtained using the binomial method.

Nonetheless, this formula is used to translate the quoted volatilities into prices.

In this paper, to analyse the relationship between strike prices and premiums, closing prices of all outstanding options contracts have been used. This also avoids the problems that would be caused by using prices taken at different times during the trading session -see Bahra (1997) and Annex 1-. In any event, it should not be forgotten that until September 1996 there are distortions in the valuations of contracts at the close of the session and that, therefore, the analysis of that period is subject to numerous caveats.

Thus, for each maturity of a call option on the MIBOR-90, daily information is available on strike prices and premiums. Assuming risk-neutral agents, and that these options behave in practice as if they were European options, the expectations distribution function can be approximated by applying equation [6]. The discount rate in that equation has been approximated by the average rate on public-debt repos between market members, at the term-to-maturity of the option.

The period used in this paper runs from January 1994, when options trading began to become significant, to May 1997. Given that the data are daily, for the sake of simplicity, for the period 1994-96, the analysis has focused on the days on which the Banco de España varied its ten-day intervention rates, as well as the immediately preceding and following days, using the options with the shortest maturity. In 1997, the analysis has been on a daily basis for the period January-May, using the options with maturity in June of that year.

The validity of the analysis depends, as mentioned in section 3, on the number of exchange-traded strike prices existing from time to time, since the aim is to approximate a continuous function from a discrete number of observed values of that function.

The approximation of the distribution function assumes that the options are of the European type, i.e. that they cannot be exercised until the maturity date. However, the options traded in the main derivative markets are of the American type (they can be exercised at any time before maturity).

In some markets such as LIFFE, the systems of margins and daily settlement of losses and gains mean that the buyer of an option does not initially make any payment, so that, in principle, there is no incentive to exercise an option before its maturity -see, for example, Gemmill (1993)-. As a result, although the options in these markets are American, they behave in practice as if they were European. In Spain, these systems are somewhat different and premiums are paid when positions are opened.

In this respect, it is worth pointing out that there would be no problem if the underlying option were MIBOR-90 instead of the future. This is because the underlying asset would not pay coupon or dividends, and therefore there would be no incentive to exercise the option early -see, for example, Hull (1991)-.

In the case of the option on the MIBOR-90 future, the option and the future mature at the same time and, therefore, the value of the option on the MIBOR-90 future is going to differ from the hypothetical value of an option on the MIBOR-90, before maturity, by the difference between the three-month spot interest rate and the interest rate of the three-month future. However, in the case of options on the MIBOR-90 future with the shortest maturity, this difference is probably not going to be very significant. Therefore, the assumption made in this paper that options on the MIBOR-90 future behave as if they were European, can be considered a reasonable simplification.

4.2. Estimation of the distribution function of expected short-term interest rates

Daily, for each maturity of options on the MIBOR-90 future, there is a probability function implicit in the relationship between strike prices and premiums. This function will vary from one day to the next insofar as agents change the probabilities attached to the various strike prices or, which comes to the same thing, to possible future interest rates, on the basis of new information received by the market.

As mentioned in section 3, the best way to characterise adequately the probability distribution of the expected values would be to estimate the density function corresponding to expected interest rates. However, this would involve attempting to approximate a continuous function from a not-very-large number of observed data -for a particular maturity, the exchange-traded strike prices and their related premiums-, so that the result would be heavily influenced by the method used to interpolate between the available data. Calculation of the distribution function presents fewer problems (though it only allows the probabilities attached to different strike price intervals to be approximated) so this has been the object of the analysis here. It should be recalled that calculation of the distribution function involves using the linear approximation of the first derivative of the function which relates, for call options, the various exchange-traded strike prices to their corresponding premiums.

On the basis of these considerations, this paper has calculated, daily, the probabilities attached to different strike price intervals for options on the MIBOR-90 future with the shortest maturity[10]. Given the volume of information entailed by daily periodicity for the period examined, it has been considered best to use certain statistics which summarise the characteristics of the distribution function. This also facilitates its comparative analysis over time.

From the set of probabilities attached to the intervals between the various exchange-traded strike prices, the aim is to draw conclusions as to certain characteristics of the density function, such as whether or not the function is normal, whether there is skewness in the distribution and whether it changes over time.

It should be pointed out that on certain dates of the period analysed the sum of the probabilities calculated is not equal to one, so that, as was to be expected, the mean rate of interest deduced from the distribution

[10] When the shortest maturity coincides with the month to which the valuation of the option refers, the next maturity is taken as the shortest. So, for example, in June call options on the MIBOR-90 future which mature in September are considered, and not those maturing in June.

estimated on such dates does not coincide with the rate of the future corresponding to that maturity. The dates on which this sum is less than one correspond to periods either when the number of exchange-traded strike prices was very small, or when economic factors existed which tended to increase significantly the uncertainty of agents. In some cases the sum of probabilities is slightly greater than one, perhaps because the approximation of the discount rate used is not, in all cases, the most suitable.

As seen in Chart 5, on all the dates analysed in 1994, except in one case, the sum of probabilities is less than 100%, ranging from 85% to 98%. It can also be seen that the daily number of exchange-traded strike prices, i.e. those quoted by market agents, started from a very low level (around nine), which increased over the year. Later, in 1995, when the Banco de España interrupted the downward path of its intervention rates (as seen in Chart 5) the sum of probabilities fell again, to levels of below 60%. Subsequently, this sum began to approach one, only to fall once more when the Banco de España resumed the downward path of its intervention rates, stabilising at one thereafter. Thus, during 1995, at times of turning points in the Banco de España intervention rates, the probabilities attached to the various strike price intervals do not permit the probability distribution to be characterised adequately. This may be because the valuations are not adequate and/or because the linear approximation used is not sufficiently precise, and/or due to lack of sufficient information on the tails of the distribution.

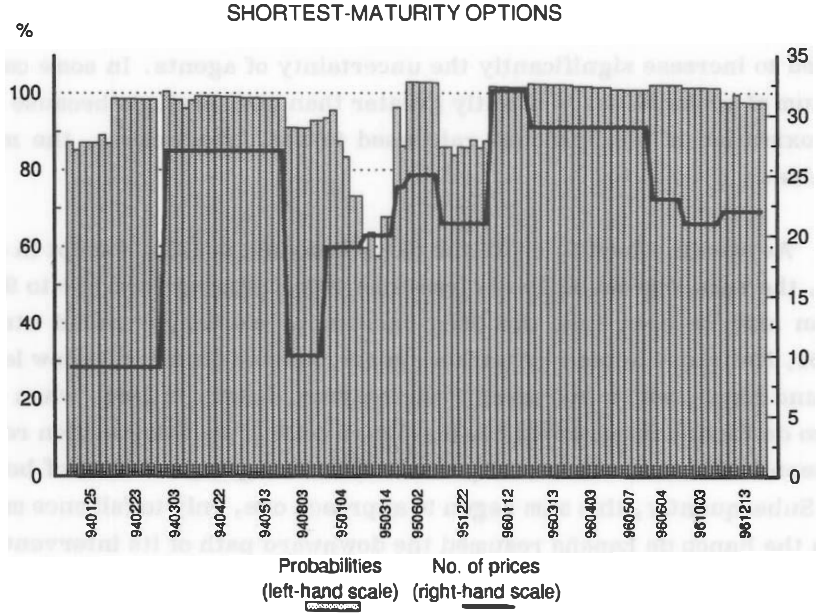
In 1996 and 1997, the data analysed reveal the increase in the number of exchange-traded strike prices. It ranged between 20 and 30, comparable to the levels in other European markets -see Neuhaus (1995) and Bahra (1997)-. During these years, on most of the dates analysed the sum of probabilities calculated is one.

The fact that, with the odd exception, the sum of the probabilities obtained for dates in 1996 and for the period January-May 1997 is one enables the set of information used to be validated to a certain extent. It should be recalled that it is as from September 1996 that the valuation of options at the close of the session is satisfactory (see section 4.1).

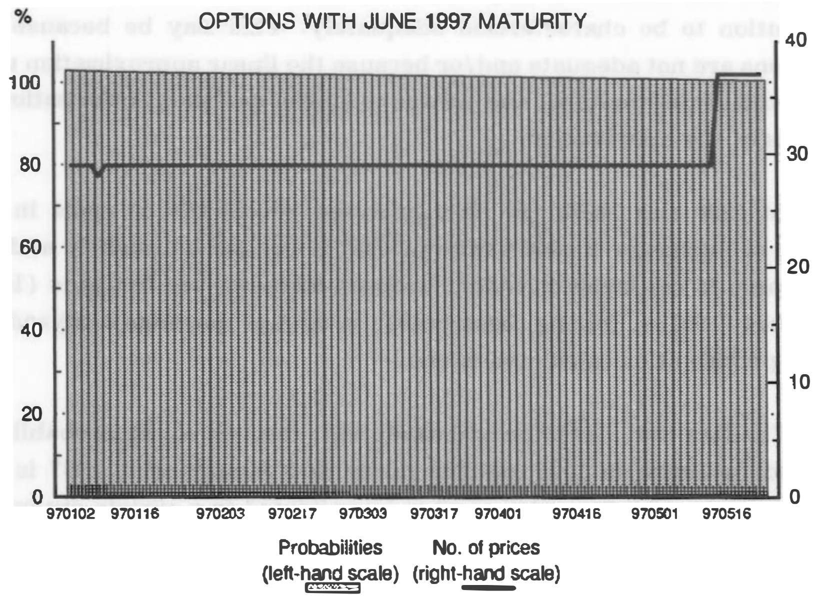
Chart 5

SUM OF PROBABILITES AND NO. OF EXCHANGE-TRADED STRIKE PRICES

SHORTEST-MATURITY OPTIONS



OPTIONS WITH JUNE 1997 MATURITY



Meanwhile, the calculation of the daily mean expected interest rate deduced from the distributions calculated allows analysis of the extent to which this coincides with the rate of interest of the future contract on the MIBOR-90, whose date of maturity coincides with the date of maturity of the option. Chart 6 shows that these rates are very similar when the sum of probabilities is equal to one.

To analyse the possible changes in the probability distributions of expected interest rates, certain statistics have been used in addition to the mean, such as the median, the range and the interquartile range[11].

Comparative analysis of the measures of central tendency -mean and median- provides information on possible skewness in the distributions. Specifically, given that the mean is influenced by the extreme values of the distribution while the median is not, if the mean is less than the median, the probability attached to the lower tail of the distribution is larger than that attached to the upper tail. In this case, skewness would be caused by a bias towards the lower values. If the mean is greater than the median the opposite would be the case.

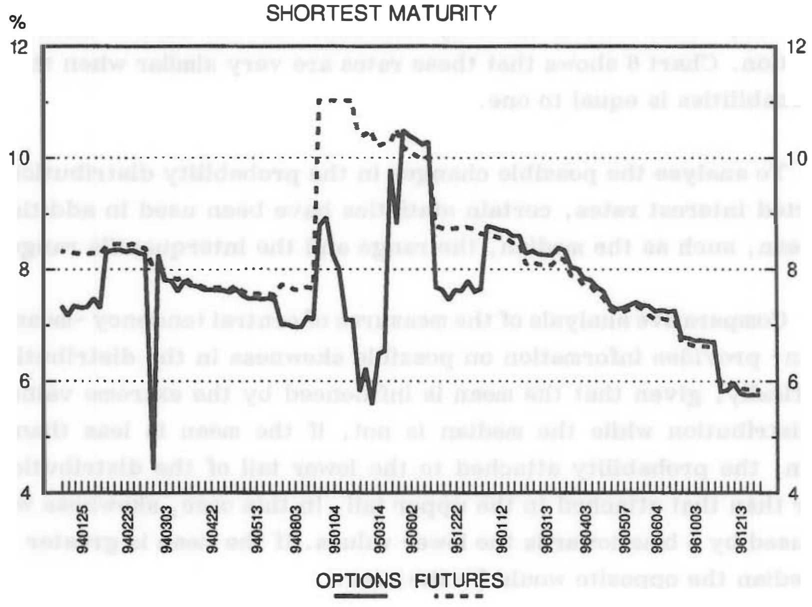
On the dates analysed in 1994 and 1995, the mean is generally below the median. The difference between them narrowed during 1994, and then widened to reach a value of around five percentage points in the first quarter of 1995. In this period there were certain temporary disturbances which increased the uncertainty in financial markets (see, for example, the 1995 Annual Report of the Banco de España), and this widening only goes to corroborate this. Thus, a higher probability than in earlier periods was attached to higher levels of interest rates. Thereafter, the difference between the mean and the median narrowed to become

[11] As is known, the range is defined as the difference between the maximum and minimum strike prices (interest rates) for which there are exchange-traded contracts and the interquartile range as the interval within which 50% of the distribution lies, which has the median as its mid-point. Thus, the interquartile range provides information on the dispersion of the distribution around the median without taking into account the tails of the distribution, so that this measure of dispersion is less influenced by atypical values.

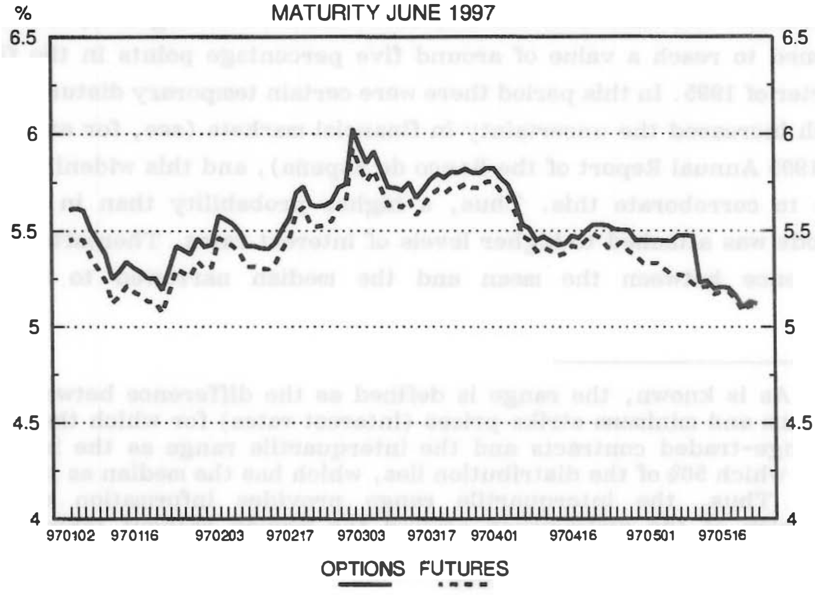
Chart 6

RATES OF INTEREST IMPLICIT IN OPTIONS AND FUTURES

SHORTEST MATURITY



MATURITY JUNE 1997



practically imperceptible in 1996, so that the distribution was more symmetrical (see upper part of charts 7 and 8).

In 1997, daily analysis of the period January-May of options with maturity in June reveals a mean slightly higher than the median and below the mode, with greater symmetry in the distribution (see lower part of Charts 7 and 8). The gap between the mode and the mean began to narrow at the beginning of April, when the expected value begins to fall significantly; it then held steady until mid-May, widening thereafter until the end of that month. The widening of the gap, discernible at the end of the period analysed, shows the strengthening of expectations of future falls in short-term interest rates.

As regards measures of dispersion, both the range of the expected interest rates, for which there are exchange-traded options contracts[12], and the interquartile range varied throughout the period considered (see upper part of Chart 9). In this respect, it should be pointed out that the dispersion indicates the uncertainty with which the market views price trends. On the dates analysed in 1994 and 1996, analysing the daily contracts with the shortest maturity on each date, the range of the sample stood at between one and two percentage points, while in 1995, it increased to stand at between three and four points. For its part, the interquartile range stood at between 50 and 75 basis points on most of the days considered, although in 1995, it exceeded 100 basis points. In any case, given that the gap between strike prices quoted by MEFF is 0.25 percentage points, 50% of the distribution is concentrated on two or three possible values of the three-month interest rate.

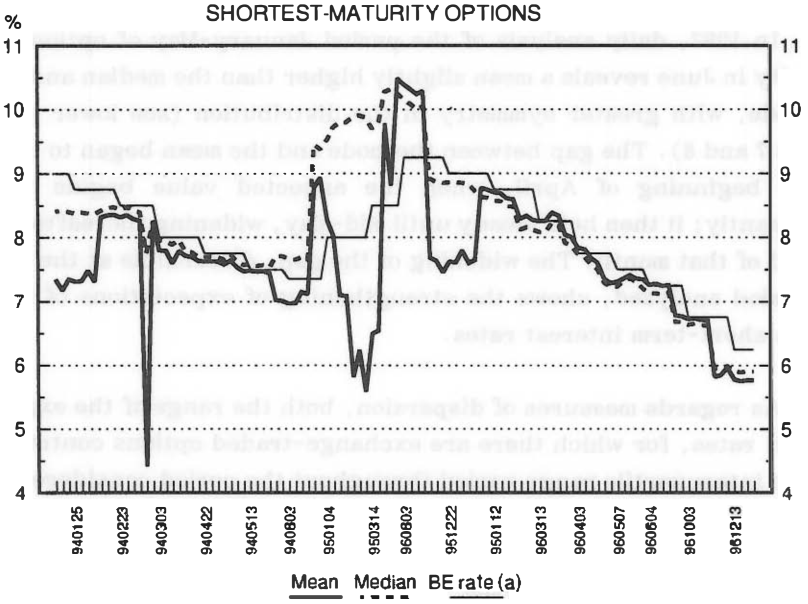
With respect to the daily analysis over the period January-May 1997 of contracts with June 1997 maturity, it is worth pointing out that the

[12] It should be taken into account that information is only available on the probabilities attached to the intervals between strike prices for which there are positions open in the market. Agents may attach a probability other than zero to certain levels of rates for which there are no contracts and which, therefore, are not taken into account in the analysis. In such cases, the sample statistics would not be a good approximation of those of the population.

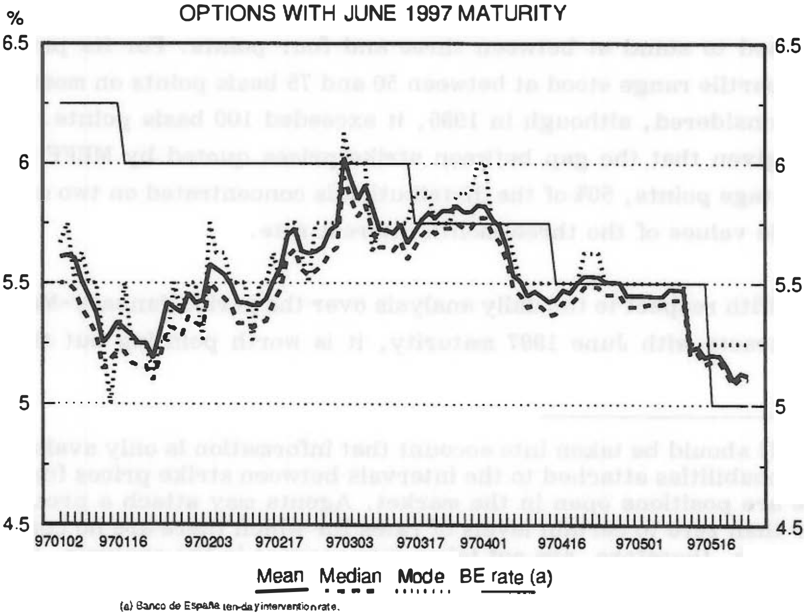
Chart 7

MEASURES OF CENTRAL POSITION OF THE IMPLICIT DISTRIBUTIONS

SHORTEST-MATURITY OPTIONS



OPTIONS WITH JUNE 1997 MATURITY

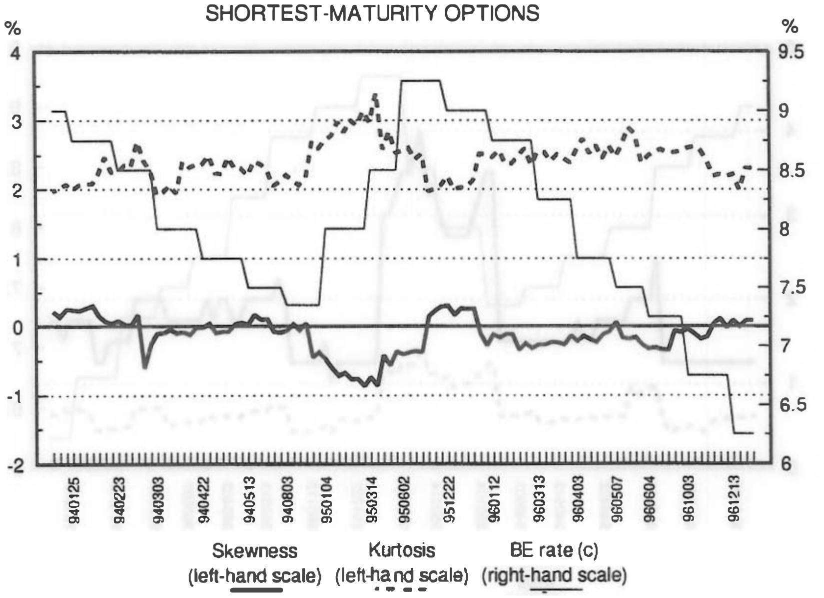


(a) Banco de España ten-day intervention rate.

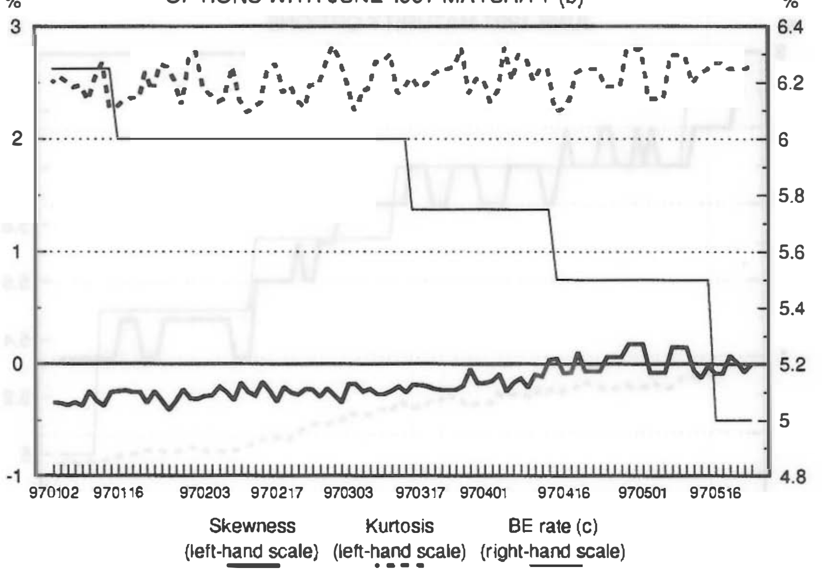
Chart 8

SKEWNESS AND KUSTOSIS IN THE IMPLICIT DISTRIBUTIONS (a)

SHORTEST-MATURITY OPTIONS



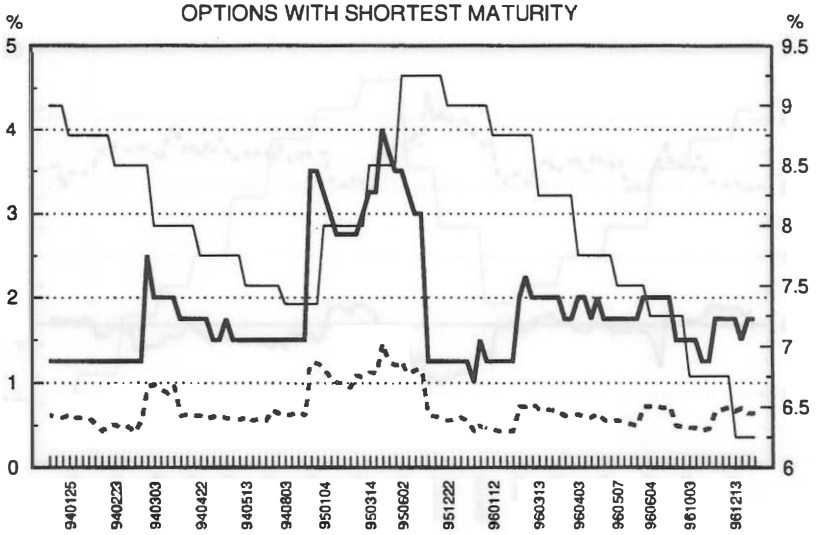
OPTIONS WITH JUNE 1997 MATURITY (b)



(a) Skewness coefficient = square of the third moment with respect to the average / standard deviation
(b) Vertical lines indicate occasions on which BE reduced its rates.
(c) Banco de España ten-day intervention rate.

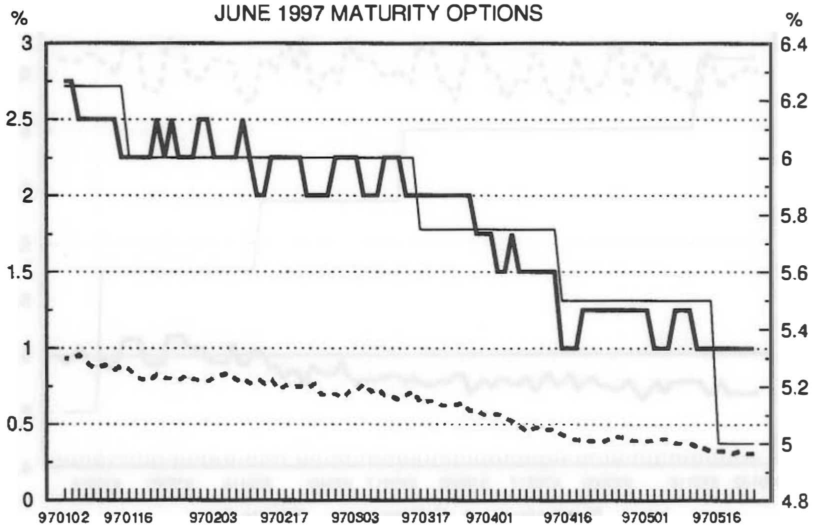
MEASURES OF DISPERSION OF THE IMPLICIT DISTRIBUTIONS

OPTIONS WITH SHORTEST MATURITY



Range total ——— Interquartile range - - - - BE rate (a) (right-hand scale) ———

JUNE 1997 MATURITY OPTIONS



Range total ——— Interquartile range - - - - BE rate (a) (right-hand scale) ———

(a) Banco de España ten-day intervention rate.

range of exchange-traded strike prices declined during the period analysed from 2.75 to 1 percentage point (see lower part of Chart 9). Likewise, the interquartile range also narrowed from 0.95 points to 0.30 points. The smaller dispersion of expectations which these statistics appear to reveal may be explained by the fact that there is probably less uncertainty about expected rates the closer the horizon to which the expectations refer. In any case, as seen in Chart 10, the movements of the first and third quartiles of the distribution increase and decrease with the arrival of new information in the market, irrespective of the time remaining to maturity.

4.3. Changes in intervention rates and effects on interest rate expectations

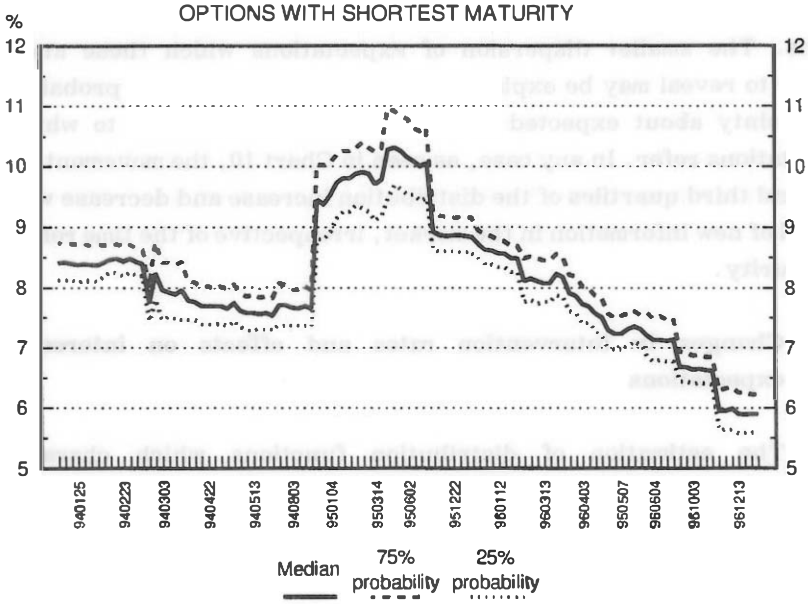
The estimation of distribution functions which characterise interest-rate expectations make it possible to analyse the extent to which the probabilities agents attach to the possible values of future interest rates are affected.

To illustrate the foregoing below, two instants have been selected from the period considered when the Banco de España varied its intervention rates. The dates selected, March 1995 and May 1997, correspond to two very different economic situations. The analysis has been carried out with the information provided by options on the MIBOR-90 future, with maturity in June of the respective years.

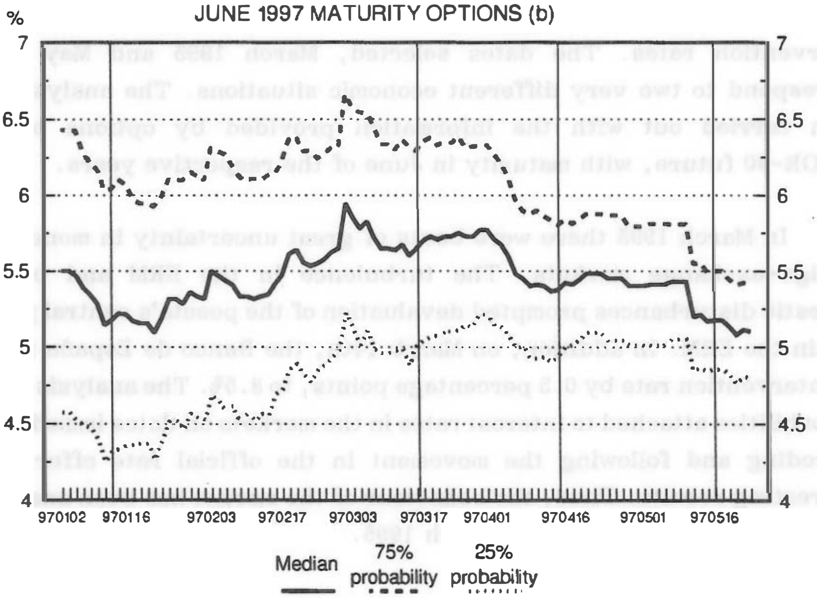
In March 1995 there were bouts of great uncertainty in money and foreign-exchange markets. The turbulence in the ERM and certain domestic disturbances prompted devaluation of the peseta's central parity within the ERM. In addition, on March 14th, the Banco de España raised its intervention rate by 0.5 percentage points, to 8.5%. The analysis of the probabilities attached to interest rates in the markets on dates immediately preceding and following the movement in the official rate offer some interesting results. Thus, the behaviour of the market has been analysed on the 10th, 14th and 16th of March 1995.

CONCENTRATION OF IMPLICIT DISTRIBUTIONS (a)

OPTIONS WITH SHORTEST MATURITY



JUNE 1997 MATURITY OPTIONS (b)



(a) Approximation of the confidence intervals.
(b) Vertical lines indicate occasions on which the BE reduced Int rates.

The upper part of Chart 11 contains a histogram showing the probabilities attached to the different interest rates on the days mentioned. And, for the purposes of illustration, Table 1 shows the distribution function estimated for the day on which the Banco de España changed its intervention rate. It should be pointed out that, on these dates, the sum of probabilities calculated is less than one (0.62, 0.66 and 0.94). Great caution must therefore be exercised when drawing conclusions about the characteristics of the distribution of expectations on these days. In any event, the data available seem to imply that the shape of the distributions is very far from that of a leptokurtic and symmetric distribution.

Over the period analysed, the range of exchange-traded strike prices increased from 2.7% percentage points on March 10th to 4 points on the 16th. In addition, on the latter date, there were exchange-traded contracts with higher strike prices (expected interest rates). A very plausible interpretation of this information is that, on these dates, the uncertainty with which agents viewed the market situation increased and the rise in the intervention rate on March 14th, breaking the downward trend of recent months, probably tended to increase the dispersion of expectations in the market, failing to reduce the uncertainty then existing.

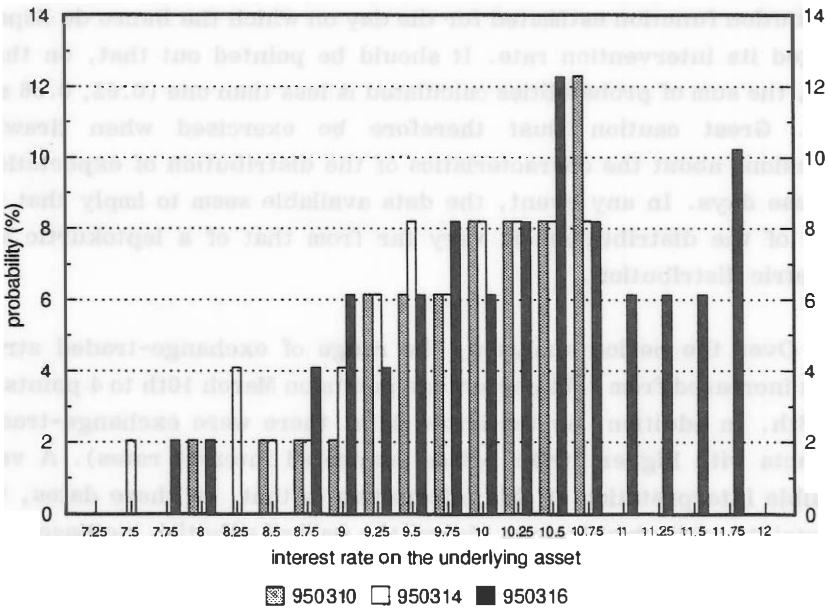
At the time of the dates chosen in 1997 the economic situation was very different from that of March 1995. In fact, on May 16th of that year, as a result of the healthy inflation outlook corroborated by the April CPI data, the Banco de España reduced its intervention rate by 0.25 percentage points, to 5.25%. Prior to this step by the central bank, interest rates in financial markets had been falling, as a consequence of an improvement in the inflation situation as perceived by agents and the economy's healthy progress with respect to the core EU countries.

As in the previous case, the lower part of Chart 11 shows a histogram of the distributions of the probability attached to possible yields on the MIBOR-90 future with maturity in June 1997 on dates preceding and following the intervention, while Table 2 gives the estimation of the distribution function corresponding to the day of the intervention. Unlike

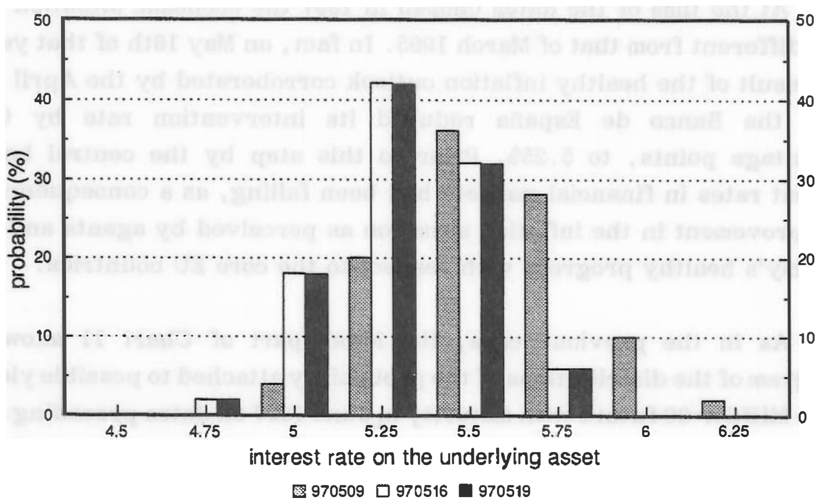
Chart 11

HISTOGRAMS OF THE IMPLICIT DISTRIBUTIONS

MATURITY: JUNE 95



MATURITY: JUNE 97



in March 1995, the sum of probabilities in this case is equal to one, and the probability distributions appear more symmetrical and concentrated around their mean values (see lower part of Chart 8). Moreover, and in contrast to the previous case, a reduction is discerned in the range of exchange-traded strike prices (from 125 to 100 basis points between May 9th and 16th). After the announcement of favourable CPI figures on May 10th, the market attached greater probability to lower values of interest rates and, accordingly, the mean values of expected rates shifted downwards. Thus, the mean and the median, whose values coincided, fell from 5.4% to 5.2%, and the mode fell from 5.5% to 5.2%. The cut in the Banco de España's intervention rate on May 16th did no more than confirm the markets' assessment of the situation, with no major changes in the distribution of expectations being discerned.

The above examples show how the information gleaned from options on interest rates can be of assistance when assessing the immediate effects of movements in intervention rates in the market, going beyond what is possible with the usual indicators.

5. SUMMARY AND CONCLUSIONS

It may be concluded from this study that the market in options on the MIBOR-90 future contains important information with respect to expectations of short-run interest rates. It can also be concluded that options on interest rates are a useful tool of analysis for monetary policy. In the Spanish case, as in other cases -see Bank of England (1997)-, such options provide indicators which contribute additional information compared to those already existing.

The characterisation of the distribution of expectations of short-term interest rates which can be deduced from the options market is important for monetary policy, both from the point of view of its design and its implementation, as it provides information on the probabilities which agents attach to the possible values of future interest rates.

The relationship existing between strike prices (the interest rates expected on the date of maturity of the option) and the related premiums gives information on the characteristics of the distribution of agents' expectations. These characteristics have been estimated in this paper on the assumption, as is usual in this kind of study, that agents are risk-neutral.

The information provided by the options market on the distributions of expectations can be extracted by various parametric and non-parametric methods -see Bahra (1996)-. The differences between them basically stem from the use a priori hypotheses as to the stochastic processes which determine the behaviour of the observed and/or expected prices in the market. In this paper no such hypothesis has been formulated and, accordingly, no characteristic has been imposed on the density function for agents' interest rate expectations. The non-parametric approach chosen has been considered the most suitable as there is no preliminary information available on the information content of the Spanish market for options on interest rates.

Non-parametric methods are based on the information contained in the function which relates, for a given underlying asset and a specific maturity, call option premiums to their respective strike prices. The distribution function of expected rates -which assigns probabilities to whether the level of the expected rate is less than or equal to a specific value- can be calculated from the first derivative of this function. The density function, which assigns to each strike price a certain probability mass, can be obtained from the second derivative.

The continuous function between strike prices and premiums is not observed in the market, but only a discrete number of points of the function. This means that it is necessary to approximate the characteristics of a continuous function from a discrete number of observed values, which makes calculation of the second derivative of this function very imprecise. Here it has been decided to calculate the distribution function from a linear approximation of the first derivative.

The method used ensures that, if the number of strike prices available is sufficiently high and options premiums are well calculated, the distribution function obtained will have certain properties, e.g. that the probabilities calculated are always positive and that the sum of the probabilities attached to the various strike price intervals is equal to one.

This paper has concentrated on analysing options on the MIBOR-90 future at the daily level for the period January 1994 to May 1997.

The analysis has made it possible, first, to verify that the data observed permit certain characteristics of the distributions of expectations in the market to be estimated which are consistent with the developments observed in the markets and with the information provided by other indicators. Second, it has been possible to make a comparison of some of the estimated characteristics of the distributions of expected interest rates at different times and, more specifically, to analyse the effects on expectations of changes in the Banco de España intervention rate in greater depth than is possible using other indicators such as the rates implicit in the yield curve or futures market rates.

The main conclusions laid bare by the analysis are that, since 1994, according to the distribution functions calculated, the symmetry and concentration of the distributions of expected rates have increased. This suggests a reduction in the degree of uncertainty with which the market views trends in short-term interest rates. This situation has been the result of a combination of various factors of an economic type, which probably include the design and implementation of monetary policy, against a background of significant nominal convergence of the economy in relation to the core EU countries.

The establishment of Monetary Union and the creation of a single money market will unify agents' expectations of short-term interest rates in the various countries. In this framework the volume of options contracts on futures on short-term interest rates will foreseeably increase. Consequently, the type of analysis presented in this paper will give a better approximation of the characteristics of the distribution of the expectations of financial agents.

The results obtained give rise to optimism as to the information which can be derived from analysis of the options market and make its extension to other kinds of contracts desirable. In this respect, and within the framework of Monetary Union, it will probably continue to be useful to analyse, for each country, options on futures on long-term interest rates, from which agents' expectations of long-term interest rate spreads may be inferred.

BIBLIOGRAPHY

Adão, B., N. Cassola y J. Barros Luis (1997): "Extracting Information from Options Premia: The Case of the Return of the Italian Lira to the ERM of the EMs", Banco de Portugal, Economic Bulletin, December.

Alonso, F. y J. Ayuso (1996): Una estimación de las primas de riesgo por inflación en el caso español. Banco de España, Servicio de Estudios, Documento de Trabajo nº 9630.

Alonso, F. et al. (1997): El poder predictivo de los tipos de interés sobre la tasa de inflación española, Banco de España, Research Department, Working Paper no. 9722.

Bahra, B. (1996): "Probability Distributions of Future Asset Prices Implied by Option Prices", Bank of England, Quarterly Report, August.

\- (1997): Implied Risk-neutral Probability Density Functions from Options Prices: Theory and Application, Bank of England, Working Paper Series no. 66, July.

Bank of England (1997): Inflation Report, May.

Breeden, D. T. and R. H. Litzenberger (1978): "Prices of State-contingent Claims Implicit in Options Prices", Journal of Business, vol. 51 no. 4, pp. 621-651.

Díaz del Hoyo, J. L. y A. J. Prado (1994): Los FRAs como indicadores de las expectativas de tipos de interés futuros, Banco de España, Research Department, Internal Document EC/1994/27.

Gemmill, G. (1993): "Options Pricing. An International Perspective", Mcgraw-Hill International.

Hull, J. (1991): "Introduction to Futures and Options Markets", Prentice-Hall International Editions.

Información Comercial Española (1992): "Los Mercados de Opciones y Futuros Financieros", Revista mensual, no. 706, June.

Jondeau, E. et M. Rockinger (1997): "Estimation et Interprétation des Densités Neutres au Risque: Une comparison de Méthodes", Banque de France, Notes d´études et de recherche, NER 47, October.

Leland, Hayne E. (1996): "Options and expectations", Journal of Portfolio Management, special issue.

Malz, Allan M. (1995): "Using Options Prices to Estimate Realignment Probabilities in the European Monetary System", Federal Reserve Bank of New York, Staff Reports no. 5, September.

Manzano, M. C. y J. A. Campoy (1997): "Algunos indicadores sobre expectativas de inflación: análisis de sus contenido informativo", Banco de España, Boletín económico, February.

Martínez Resano, J. R. (1997): Los mercados de derivados y el EURO, Banco de España, Research Department, Working Paper no. 9709.

MEFF (1995): Reglamento del Mercado de Futuros Financieros, S.A.

- (1997): Newsletter. Technical Notes, January no. 43 and June no. 48.

Neuhaus, H. (1995): "The Information Content of Derivatives for monetary policy. Implied Volatilities and Probabilities", Deutsche Bundesbank, Discussion Paper 3795, July.

Núñez Ramos, S. (1992): FRAs, futuros y opciones sobre el MIBOR, Banco de España, Research Department, Working Paper no. 9211.

Restoy, F. (1995): Determinantes de la curva de rendimientos: hipótesis expectacional y primas de riesgo, Banco de España, Research Department, Working Paper no. 9530.

Rubinstein, M. (1994): "Implied binomial trees", Journal of Finance, vol. 69, no. 3, July, pp. 771-818.

Söderlind, P. and Lars E. O. Svensson (1996): "New Techniques Market Expectations from Financial Instruments". Institute for International Economic Studies, Seminar Paper, no. 621.

ANNEX 1. Valuation of options. Closing prices

As mentioned above, the options prices used in this paper correspond to the closing prices used daily by MEFF to value open positions and to settle market members' losses and gains.

Closing prices are very suitable for several reasons. First, the prices relate to the same moment of time, which avoids distortions in the valuations of contracts owing to non-simultaneity of prices. Second, these prices, which are the mean, for each strike price and each maturity, of the prices obtained from a survey of a group of agents (volatility club), avoid the valuations being based on transactions between agents with different price expectations.

For example, Chart A.1 depicts two sets of prices corresponding to the different strike prices with a solid and a dotted line. It can be assumed that the two sets either correspond to the valuations of two different agents or else correspond to market valuations at different times.

The probability assigned to the price of the underlying asset being between the strike prices 91.25 and 91.50 is 40%[13] in both cases. Had the valuations used for the various strike prices been those indicated with the letters A, B, C and D in the Chart, the probability associated with the aforementioned interval would be only 20%.

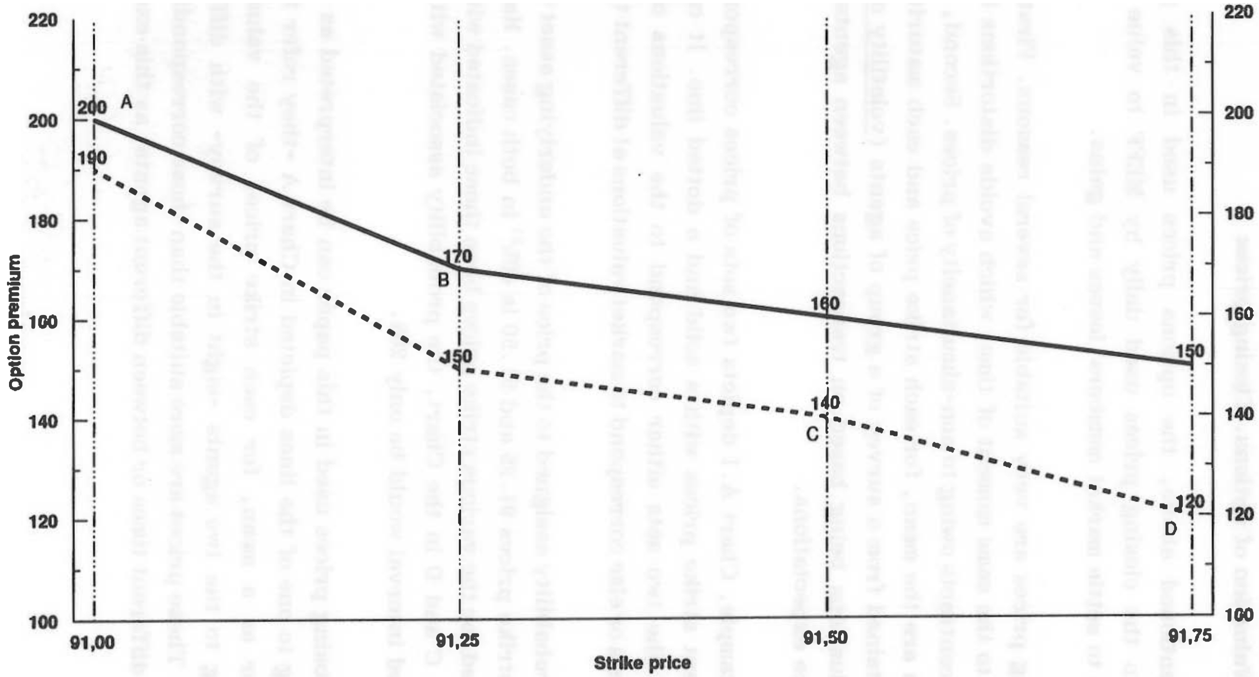
The closing prices used in this paper can be interpreted as those corresponding to one of the lines depicted in Chart A -they refer to the same time- or as a mean, for each strike price, of the valuations corresponding to the two agents -eight in the survey- with different expectations. These prices are more suitable than those corresponding to operations at different times or between different agents, as this example illustrates.

---

[13] This probability has been calculated using the non-parametric method set out in this paper.

Chart A.1

OPTIONS



WORKING PAPERS (1)

9616 **A. Jorge Padilla, Samuel Bentolila and Juan J. Dolado:** Wage bargaining in industries with market power.

9617 **Juan J. Dolado and Francesc Marmol:** Efficient estimation of cointegrating relationships among higher order and fractionally integrated processes.

9618 **Juan J. Dolado y Ramón Gómez:** La relación entre vacantes y desempleo en España: perturbaciones agregadas y de reasignación.

9619 **Alberto Cabrero and Juan Carlos Delrieu:** Construction of a composite indicator for predicting inflation in Spain. (The Spanish original of this publication has the same number.)

9620 **Una-Louise Bell:** Adjustment costs, uncertainty and employment inertia.

9621 **M.ª de los Llanos Matea y Ana Valentina Regil:** Indicadores de inflación a corto plazo.

9622 **James Conklin:** Computing value correspondences for repeated games with state variables.

9623 **James Conklin:** The theory of sovereign debt and Spain under Philip II.

9624 **José Viñals and Juan F. Jimeno:** Monetary Union and European unemployment.

9625 **María Jesús Nieto Carol:** Central and Eastern European Financial Systems: Towards integration in the European Union.

9626 **Matthew B. Canzoneri, Javier Vallés and José Viñals:** Do exchange rates move to address international macroeconomic imbalances?

9627 **Enrique Alberola Ila:** Integración económica y unión monetaria: el contraste entre Norteamérica y Europa.

9628 **Víctor Gómez and Agustín Maravall:** Programs TRAMO and SEATS.

9629 **Javier Andrés, Ricardo Mestre y Javier Vallés:** Un modelo estructural para el análisis del mecanismo de transmisión monetaria: el caso español.

9630 **Francisco Alonso y Juan Ayuso:** Una estimación de las primas de riesgo por inflación en el caso español.

9631 **Javier Santillán:** Política cambiaria y autonomía del Banco Central.

9632 **Marcial Suárez:** Vocábula (Notas sobre usos lingüísticos).

9633 **Juan Ayuso and J. David López-Salido:** What does consumption tell us about inflation expectations and real interest rates?

9701 **Víctor Gómez, Agustín Maravall and Daniel Peña:** Missing observations in ARIMA models: Skipping strategy versus outlier approach.

9702 **José Ranón Martínez Resano:** Los contratos DIFF y el tipo de cambio.

9703 **Gabriel Quirós Romero:** Una valoración comparativa del mercado español de deuda pública.

9704 **Agustín Maravall:** Two discussions on new seasonal adjustment methods.

9705 **J. David López-Salido y Pilar Velilla:** La dinámica de los márgenes en España (Una primera aproximación con datos agregados).

9706 **Javier Andrés and Ignacio Hernando:** Does inflation harm economic growth? Evidence for the OECD.

9707 **Marga Peeters:** Does demand and price uncertainty affect Belgian and Spanish corporate investment?

9708 **Jeffrey Franks:** Labor market policies and unemployment dynamics in Spain.

9709 **José Ramón Martínez Resano:** Los mercados de derivados y el euro.

9710 **Juan Ayuso and J. David López-Salido:** Are *ex-post* real interest rates a good proxy for *ex-ante* real rates? An international comparison within a CCAPM framework.

9711 **Ana Buisán y Miguel Pérez:** Un indicador de gasto en construcción para la economía española.

9712 **Juan J. Dolado, J. David López-Salido and Juan Luis Vega:** Spanish unemployment and inflation persistence: Are there phillips trade-offs?

9713 **José M. González Mínguez:** The balance-sheet transmission channel of monetary policy: The cases of Germany and Spain.

9714 **Olympia Bover:** Cambios en la composición del empleo y actividad laboral femenina.

9715 **Francisco de Castro and Alfonso Novales:** The joint dynamics of spot and forward exchange rates.

9716 **Juan Carlos Caballero, Jorge Martínez y M.ª Teresa Sastre:** La utilización de los índices de condiciones monetarias desde la perspectiva de un banco central.

9717 **José Viñals y Juan F. Jimeno:** El mercado de trabajo español y la Unión Económica y Monetaria Europea.

9718 **Samuel Bentolila:** La inmovilidad del trabajo en las regiones españolas.

9719 **Enrique Alberola, Juan Ayuso and J. David López-Salido:** When may peseta depreciations fuel inflation?

9720 **José M. González Mínguez:** The back calculation of nominal historical series after the introduction of the european currency (An application to the GDP).

9721 **Una-Louise Bell:** A Comparative Analysis of the Aggregate Matching Process in France, Great Britain and Spain.

9722 **Francisco Alonso Sánchez, Juan Ayuso Huertas y Jorge Martínez Pagés:** El poder predictivo de los tipos de interés sobre la tasa de inflación española.

9723 **Isabel Argimón, Concha Artola y José Manuel González-Páramo:** Empresa pública y empresa privada: titularidad y eficiencia relativa.

9724 **Enrique Alberola and Pierfederico Asdrubali:** How do countries smooth regional disturbances? Risksharing in Spain: 1973-1993.

9725 **Enrique Alberola, José Manuel Marqués and Alicia Sanchís:** Unemployment persistence, Central Bank independence and inflation performance in the OECD countries. (The Spanish original of this publication has the same number.)

9726 **Francisco Alonso, Juan Ayuso and Jorge Martínez Pagés:** How informative are financial asset prices in Spain?

9727 **Javier Andrés, Ricardo Mestre and Javier Vallés:** Monetary policy and exchange rate dynamics in the Spanish economy.

9728 **Juan J. Dolado, José M. González-Páramo y José Viñals:** A cost-benefit analysis of going from low inflation to price stability in Spain.

(1) Previously published Working Papers are listed in the Banco de España publications catalogue.

Queries should be addressed to: Banco de España
Sección de Publicaciones. Negociado de Distribución y Gestión
Telephone: 91 338 5180
Alcalá, 50. 28014 Madrid