

appreciate by degrees in the forecast period, to an index level of approximately 121 in twelve months time and approximately 118 after twenty-four months.²² This means that, compared with the December assessment, the krona is judged to be stronger in the first half of 1999, followed by broadly the same path as envisaged earlier.

Short-term interest rates are assumed to be more or less stationary in the forecast period, given the underlying assumption of an unchanged repo rate. Longer Swedish bond rates are

assumed to rise around half of a percentage point up to the end of the forecast period. As previously, the krona is judged to appreciate.

20 Since the period of unrest in connection with the outcome of the general election in Sweden in September 1998, this differential has narrowed from around one percentage point to approximately 0.4 percentage points, which can be interpreted as a stabilisation of confidence in the Swedish economy.

21 See *Inflation Report 1998:3*, box on pp. 27-29.

22 This assessment is largely in line with the expectations of money market investors (Annex: Table 1).

CURRENCY OPTION PRICES AS INDICATORS OF MARKET EXPECTATIONS

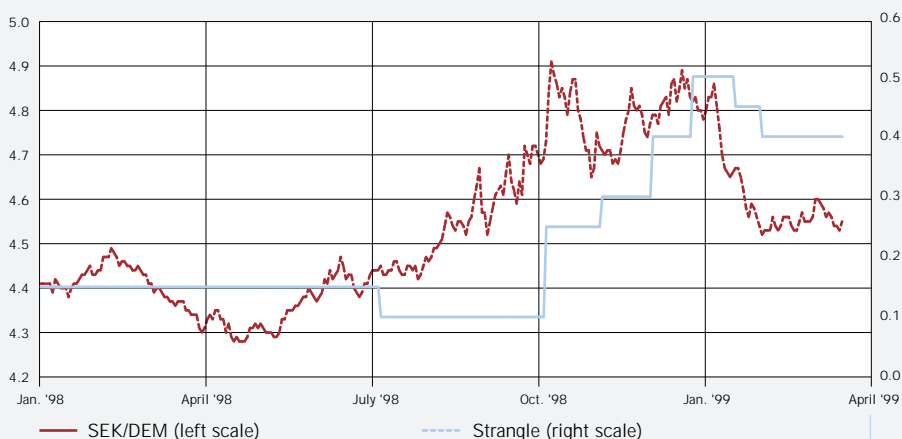
The krona has strengthened relatively rapidly since the turn of 1998, against the euro by about 6 per cent. The appreciation is natural in that last autumn's financial unrest, which contributed to a marked weakening of the krona, has now subsided. The recovery may have been aided by rising expectations that Sweden will join the euro area. Some market players have expressed fears that the appreciation has been unduly hasty, with some risk of a rebound. This prompts the question of whether such risks are included in market prices. Currency option prices provide an opportunity of investi-

gating this and to some extent of quantifying market uncertainty.

More specifically, the pricing of different combinations of currency options (FX options) can be used to form a picture of market perceptions of the degree of uncertainty and any asymmetries in risk assessments.²³

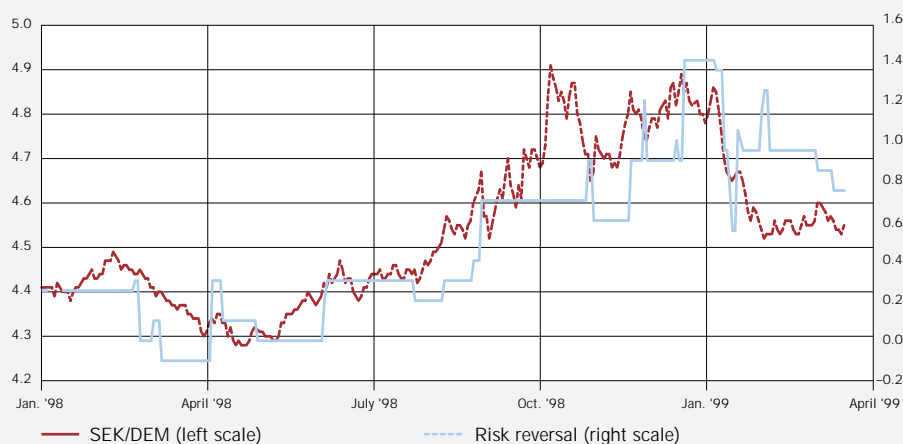
FX options are mostly traded in the over-the-counter (OTC) market, where combinations of out-of-the-money call options and out-of-the-money put options are common.²⁴ Two very frequent combinations are known as strangles and risk reversals. These deriv-

Figure B2.
SEK/DEM exchange rate and derived 1-month strangle



Sources: Reuters and the Riksbank.

Figure R3.
SEK/DEM exchange
rate and derived
1-month risk reversal



Sources: Reuters and the Riksbank.

ative instruments with a maturity of one month for the SEK/DEM exchange rate²⁵ are studied here to illustrate the interpretation of option prices in terms of expectations.

Strangle—an indicator of large exchange rate movements

A strangle involves buying both a put and a call option that are out-of-the-money in the belief that price movements during their life will be pronounced—the call (put) option can only be exercised if the price of the underlying asset rises (falls) markedly.²⁶ A strangle is priced in the market as the difference between the average of the two options' implied volatility and the at-the-money volatility. The price therefore reflects the perception of the risk of outcomes that are extreme relative to the market's volatility forecast.²⁷

A time series of a strangle's price provides information about variations in market expectations of the probability of large exchange rate movements. The SEK/DEM exchange rate and strangle since the beginning of 1998 are shown in Fig. B2.

In the early autumn of 1998 Russia's difficulties with debt payments were accompanied by pronounced financial market turbulence. As investors transferred assets to larger currencies, the krona weakened. Fig. B2 shows that the price of an SEK/DEM strangle rose as

the krona weakened against the German mark, which can be interpreted as market perceptions of growing uncertainty about the future exchange rate. Although the financial market unrest has subsided and the krona has recently strengthened, the strangle price has fallen only marginally. This suggests that the market is still uncertain about the krona's future path and considers that the risk of large exchange rate movements (beyond the expected volatility) is still relatively high.

Risk reversal—an indicator of asymmetries in the uncertainty

A risk reversal involves buying a call option and selling a put option, in both cases out-of-the-money. It is accordingly priced as the implied volatility spread between these two options. A risk reversal is bought in the belief that it is more likely that the call option will end up in-the-money, than that the put option will. In this case the investor perceives a greater probability of positive compared with negative returns from the underlying exchange rate (in the case of SEK/DEM, an assessment that the krona is more likely to depreciate than appreciate against the German mark). The price of a risk reversal may therefore indicate the market's perception of whether the exchange rate uncertainty is mainly on the upside or the downside.²⁸

The time series of the SEK/DEM exchange rate

and risk reversal are shown in Fig. B3. It will be seen that the exchange rate and the price of the risk reversal co-vary. When the krona weakens against the German mark, the price of the risk reversal tends to rise.

The curves show that when the krona weakened in the autumn of 1998, the price of the risk reversal rose sharply. Moreover, the price has clearly not fallen back in connection with the krona's recent appreciation against the euro. This suggests that, despite the krona's appreciation, the market still considers that a marked weakening of the krona is more probable than a marked strengthening.

In conclusion, option prices show that the market still considers that the uncertainty about the krona's future path is relatively high. The price of an SEK/DEM strangle indicates perceptions of a relatively large risk of marked exchange rate movements in the near future. Judging from the clearly positive price of an SEK/DEM risk reversal, moreover, the market seems to believe that a depreciation of the krona against the German mark (and hence the euro) is more probable than an appreciation. The market may conceivably consider that the krona's recent appreciation has been too hasty, which can be interpreted as the perception of a risk of a rebound in the near future.

23 For a more detailed discussion of the interpretation of information conveyed by option prices, see Aguilar, J & Hördahl, P. (1999), Option prices and market expectations, *Quarterly Review* 1, Sveriges Riksbank.

24 A SEK/DEM call option gives the holder the right to buy German marks for Swedish kronor in the future at an agreed price. An option is *out-of-the-money* when the exercise price of a call (put) option, that is, contracts to buy and sell, respectively, is above (below) the current forward price of the underlying asset (the asset on which the option is written); in the opposite case the option is *in-the-money*; options are *at-the-money* when the exercise price equals the forward price.

25 The SEK/EUR rate is used after the turn of 1998. In the figures the SEK/DEM rate in 1999 has been derived from the DEM/EUR conversion rate.

26 In OTC markets for FX derivatives, options are invariably priced in terms of implied volatility, not in money. The price to be paid on an option contract is derived from the agreed volatility, using the Black-Scholes model. This does not necessarily mean the market participants believe the model is valid; it simply serves as a formula for transforming volatility into prices and vice versa.

27 Thus, the price of a strangle is associated with the degree of kurtosis in the implied probability distribution of the underlying exchange rate. Kurtosis is a statistical measure of how peaked the probability distribution is and the fatness of its tail—the higher the value of a strangle, the higher will be the kurtosis in the distribution.

28 The price of a risk reversal is directly related to the skewness (asymmetry) of the implied probability distribution for the underlying exchange rate. A positive (negative) value of a risk reversal is associated with positive (negative) skewness, that is, a larger proportion of the total probability is in the right- (left-) hand tail.

Import prices

Import prices affect inflation in two ways. Changes in international export prices and the krona's exchange rate have a *direct* impact on consumer prices because a sizeable part of the CPI base consists of imported goods and substitutes for imports. Moreover, movements in international prices and the exchange rate affect inflation *indirectly* via effects on the relationship between domestic demand and supply.

The link between international price movements for commodities and manufactured products on the one hand and Swedish producer and consumer prices on the other is complex. The exchange rate

is important for the prices to producers but the pass-through, particularly for manufactured goods, is liable to be incomplete and lagged. This is even more the case for the pass-through to consumer prices. Estimates suggest that the lag before consumer prices are affected by movements in international prices for manufactured products and the exchange rate may amount to several years.²⁹ The pass-through for commodity prices is considerably faster, probably because these items are homogeneous and priced in the world market (Fig. 8).

29 See *Inflation Report 1998:4*, box on pp. 27-28.