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THE SIMPLEST TEST OF
TARGET ZONE CREDIBILITY

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ABSTRACT

A credible target zone exchange rate regime with a given exchange rate band implies bounds on the amount of depreciation and appreciation of the domestic currency. This implies, for given foreign interest rates, bounds on the domestic-currency rate of return on foreign investment: a rate-of-return band for each time to maturity. Whether domestic interest rates are outside these rate-of-return bands can be used as a simple test of exchange rate credibility, under the assumption of sufficient international capital mobility. This test is applied to the Swedish target zone during February 1986-February 1990.

Under the additional assumption of uncovered interest rate parity, an equivalent test is whether expected future exchange rates are outside the exchange rate band. In addition, the expected future exchange rates are used to give an estimate of the probability of future devaluations.

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1. Introduction

An exchange rate target zone with an explicit band for the exchange rate implies bounds on the amount of depreciation and appreciation of the exchange rate, since the exchange rate cannot move further than to the edges of the band. Given foreign interest rates, these bounds on the amount of depreciation and appreciation imply bounds on domestic currency rates of return to foreign investment. These rate-of-return bounds define a rate-of-return band around the foreign interest rates. The rate-of-return bands are narrower for longer terms (times to maturity), since the maximum amount of appreciation and depreciation per unit term is decreasing in the term.

Suppose there is sufficiently free international capital mobility. If the domestic interest rate for some terms is outside the rate-of-return band for that term, and if capital inflows are not large, the exchange rate regime cannot be completely credible within the horizon given by the term. That is, investors must perceive a risk of a change in the regime, for instance a devaluation, before maturity. For if the target zone was considered completely credible there would be completely safe arbitrage, and huge capital flows would arise.

Therefore, whether or not the domestic interest rates are within the rate-of-return bands can be used as a very simple and most straightforward test of the credibility of a target zone. If the interest rates are within the rate-of-return bands it does not necessarily follow that the target zone is credible, but if the interest rates fall outside the band it definitely follows that the target zone is not credible (if there is sufficient international capital mobility and capital flows are not large).

Grønvik (1986) discussed rate-of-return bands (called "interest rate corridors") in a study of the Norwegian forward foreign exchange market. He argued that they should be interpreted as constraints on domestic monetary policy and domestic interest rates. He computed a 3-month rate-of-return band for Norway during the period 1983-85 and

showed that the Norwegian 3-month interest rate was above the rate-of-return band during the end of 1984 and 1985. This fact was used to explain the large growth of the Norwegian forward exchange market and increasing attempts to circumvent the Norwegian capital controls.

Here we shall assume that there is sufficient capital mobility between Sweden and the rest of the world, and we shall consequently apply the rate-of-return bands as a simple test of the credibility of the Swedish target zone. Separately, we also examine the volume of capital flows.¹

Under the additional assumption of uncovered interest rate parity, expected future exchange rates can be computed from current spot exchange rates and domestic and foreign interest rates for different maturities. Whether or not the domestic interest rate for the corresponding maturity is inside its rate-of-return band is then equivalent to whether or not the expected future exchange rate at maturity is inside the exchange rate band. Then target zone credibility can be tested by examining whether the expected future exchange rate is inside or outside the exchange rate band.²

Also, under the assumption of uncovered interest rate parity, the lack of credibility of the target zone can be *quantified*, in that the expected rate of depreciation for different terms, adjusted for the rate of depreciation consistent with a credible exchange rate band, can be used as a measure of the expected rate of *devaluation*. Under additional assumptions about the stochastic process of devaluations and the size of devaluations, the perceived probability of devaluations per unit of time can be estimated.

Section 2 and 3 define rate-of-return bands, expected rates of depreciation and expected rates of devaluation. Section 4 examines data from the Swedish target zone

¹ Swedish capital controls the last few years have generally been considered very ineffective, with many ways of circumventing them. The capital controls have been gradually dismantled, in particular since January 1989, and since June 1989 they are for all practical purposes abolished.

² Mats Persson has in lecture notes independently examined the credibility of the Swedish target zone by computing expected future exchange rates.

during the period February 1987 - April 1990 (the period is determined by the availability of interest rate data). Section 5 concludes. An appendix presents some technical details.

2. The Rate-of-Return Band

Let S_t , i_t^T , and i_t^{*T} denote, respectively, the spot exchange rate in period t (in units of domestic currency per unit of foreign currency), the domestic-currency interest rate in period t for term- τ loans in domestic currency, and the foreign-currency interest rate in period t for term- τ loans in foreign currency. (The "foreign currency" may be a particular foreign currency, or a basket of several foreign currencies.) Let us measure the term τ in months, and let the interest rates be annualized effective interest rates. The annualized effective domestic-currency ex post rate of return on a foreign currency investment in period t of duration τ , R_t^T , is then given by

$$(1) \quad R_t^T = (1 + i_t^{*T})(S_{t+\tau}/S_t)^{12/\tau} - 1.$$

This expression can be understood as follows. Investing one unit of domestic currency means investing $1/S_t$ units of foreign currency. This invested in a τ -month foreign currency bond results in $(1 + i_t^{*T})^{\tau/12}/S_t$ units of foreign currency after τ months (recall that i_t^{*T} is the annualized effective interest rate). This is $(1 + i_t^{*T})^{\tau/12}S_{t+\tau}/S_t$ units of domestic currency, which equals $(1 + R_t^T)^{\tau/12}$, where R_t^T is the annualized effective domestic-currency rate of return. The result can be written as in (1).

Suppose the exchange rate is restricted to a band with lower and upper bounds \underline{S} and \bar{S} ,

$$(2) \quad \underline{S} \leq S_t \leq \bar{S}.$$

The exchange rate band implies bounds on the amount of depreciation and appreciation of the domestic currency. This implies that the rates of return R_t^T will also be restricted to a band,

$$(3) \quad \underline{R}_t^T \leq R_t^T \leq \bar{R}_t^T,$$

which we will call the rate-of-return band. The lower and upper bounds on the rates of return are given by

$$(4a) \quad R_t^r = (1 + i_t^{*r})(S/S_t)^{12/\tau} - 1 \text{ and}$$

$$(4b) \quad R_t^r = (1 + i_t^{*r})(S/S_t)^{12/\tau} - 1.$$

The bounds are decreasing in the current exchange rate: A higher exchange rate means a weaker domestic currency, which increases the scope for domestic currency appreciation. This lowers the domestic currency rate of return on foreign investments and shifts down the rate-of-return band. The width of the rate-of-return band is decreasing in the term: A given relative change in the exchange rate during a longer time period implies a smaller relative change per unit of time. Therefore the upper bound of the rate of return is decreasing in the term, and the lower band is increasing.

Under a completely credible exchange rate regime, and with free capital mobility, the domestic interest rate i_t^r must lie inside the rate-of-return band (3). For if the domestic interest rate is outside the rate-of-return band there is completely safe arbitrage: If the domestic interest rate is above (below) the rate-of-return band, an agent can borrow (lend) abroad and lend (borrow) at home and make a safe profit. Such safe arbitrage would not be compatible with an equilibrium in the world capital market.

Therefore, if indeed the domestic interest rate in some period and for some maturity is outside the rate-of-return band (2), and if capital is sufficiently internationally mobile, the exchange rate regime cannot be completely credible. That is, investors perceive a risk of a change in the exchange rate regime, for instance a devaluation (a shift in the band). Therefore, the simplest test of whether the exchange rate band is completely credible is to check whether domestic interest rates are inside the rate-of-return band, in different periods and for different maturities. This we shall do below, for the Swedish target zone.

3. Expected Exchange Rates and Expected Rates of Depreciation

Let us now make the additional assumption of uncovered interest rate parity: that the expected home currency depreciation compensates for the interest rate differential between home and foreign interest rates such that the expected rate of return on a home-currency investment equals the expected rate of return on a foreign-currency investment.³

We can write uncovered interest rate parity on the form

$$(5) \quad {}_t S_{t+\tau} = S_t \left[\frac{1 + i_t^\tau}{1 + i_t^* \tau} \right]^{\tau/12}$$

where ${}_t S_{t+\tau}$ denotes the expected value in month t of the exchange rate to rule in month $t+\tau$. Hence, from a particular month's exchange rate and domestic and foreign interest rates for bonds with τ months to maturity, we can compute the month's expectation of the exchange rate τ months later.

Whether the domestic interest rate in month t is inside or outside the rate-of-return band for a particular term of τ months is then equivalent to whether the month's expectation of the exchange rate in month $t+\tau$ is inside or outside the exchange rate band. Therefore, an alternative way to illustrate the credibility of a target zone is to compute the expected future exchange rates according to (5), and then examine whether the expected future exchange rates are inside or outside the exchange rate band. This we shall also do below, for the Swedish target zone.

Given expected future exchange rates computed by (5), we can compute expected annualized rates of depreciation d_t^τ from month t to month $t+\tau$ according to

$$(6) \quad d_t^\tau = ({}_t S_{t+\tau} / S_t)^{12/\tau} - 1.$$

Replacing the expected exchange rate in (6) by the lower and upper bounds for the exchange rate, \underline{S} and \bar{S} , we get the minimum and maximum rates of depreciation

³ Svensson (1990a) demonstrates that any foreign exchange risk premium in a relatively narrow target zone should be small, also when there is devaluation risk. Therefore uncovered interest rate parity should be a good approximation for narrow target zones.

compatible with a credible exchange rate band, d_t^r and \bar{d}_t^r . By (5) the annualized expected rates of depreciation in (6) are of course just annualized interest rate differentials and fulfill

$$(7) \quad d_t^r = \frac{1 + i_t^r}{1 + i_t^{*r}} - 1.$$

We shall also compute and discuss these expected rates of depreciation. We shall see that they need to be interpreted with some care:

More specifically, we make the additional assumption that devaluations are expected to occur regularly over time with a probability λ per unit of time. This implies that devaluations are assumed to follow a so called Poisson stochastic process.⁴ Furthermore, we assume that devaluations, if and when they occur, are expected to be of a given size g (measured in percent). Then the expected rate of devaluation per unit time, d (measured in percent per unit of time), is simply the product of the probability per unit time of a devaluation and the size of a devaluation,

$$(8) \quad d = \lambda g.$$

Excess of the expected rate of depreciation over the maximum rate of depreciation compatible with the target zone indicates a positive expected rate of devaluation. From this expected rate of devaluation, assuming a given size of a devaluation, the corresponding probability per unit of time of a devaluation can be computed.

4. Swedish Data

Sweden has a unilateral exchange rate target zone. An exchange rate index is defined as the exchange rate between the Krona and a currency basket consisting of the trade-weighted currencies of Sweden's fifteen largest trade partners (with double weight

⁴ See Svensson (1990a,b) for further details on a model of a target zone with devaluations being a Poisson process.

for the dollar). The basket exchange rate is restricted to a band around a benchmark rate. The benchmark rate has been fixed at 132 since the latest devaluation in September 1982. The bandwidth was first kept secret at ± 2.25 percent around the benchmark. In June 1985 the bandwidth was reduced to ± 1.5 percent (between 130 and 134) and made public.⁵

The data consists of monthly observations (last trading day of the month) for the period February 1987 to April 1990 of the basket exchange rate, Krona interest rates for Swedish Treasury Bills and government bonds of terms 1, 3, 6, 12 and 60 months, corresponding Euro interest rates and, for 60 months to maturity, national bond interest rates, for most of the currencies in the basket. Long term interest rates for some basket currencies are not easily available for the period before February 1987.

4.1 Rate-of-Return Bands

Using the weights of the currency basket, foreign basket interest rates have been computed. Then the lower and upper bounds of the Krona rates of return on foreign basket investment have been computed according to (4), for each month and for the different maturities.

The resulting rate-of-return bands' dependence on the exchange rate is illustrated in *Figure 1*. The bottom solid curve shows the basket exchange rate's percentage deviation, e , from the benchmark rate [$e = 100(S - 132)/132$ percent] during the period February 1987-April 1990.⁶ That is, in *Figure 1* the benchmark rate is at 0 percent, and the exchange rate band is between plus and minus 1.5 percent, shown as dashed horizontal lines. (Positive values indicate a weak Krona.) The months are numbered consecutively so that the first observation, February 1987, is month number 2. The two dashed curves in the upper part of the *Figure* show the upper and lower bounds on the rate of return on

⁵ For details, see Ringström (1987).

⁶ Since (because of a labor market conflict in the banking industry) Swedish interest rates are missing for month 37 (January 1990), all observations for that month are for convenience set equal to an average between the observation for month 36 and 38. The actual exchange rate for the last trading day of month 37 was 132.2, 0.15 percent above the benchmark value. The actual exchange rate in month 37 is plotted in *Figure 7* below.

a 12 month foreign currency basket investment. The top solid curve shows the 12-month basket interest rate. We see that when the exchange rate is near its benchmark rate, for instance in month 12 (December 1987), the rate-of-return is about ± 1.5 percent around the basket interest rate, since then the exchange rate can either appreciate or depreciate 1.5 percent. We also see that when the exchange rate is at the lower edge of its band (when the Krona is strong), for instance in month 16 (April 1988), the rate-of-return band shifts up and is between 0 and +3 percent relative to the basket interest rate, since then the home currency can only depreciate. For a 60 month term, the width of the rate-of-return band will decrease to about a fifth, and for a 6 month term it will increase to about double the width for a 12 month term ("about" rather than "exactly" because compound rates of return are used).

Figure 2 shows the rate-of-return band (the top and bottom dashed curves) and the basket interest rate (the bottom solid curve). Also shown is the 3-month Krona Treasury Bill interest rate (the top solid curve). We see that the Krona interest rate is above the basket interest rate, but that the Krona interest rate is well into the rate-of-return band. From the 3-month interest rate we cannot here find any evidence of a devaluation risk. This is also the case for the 1-month interest rate where the band is about three times wider (not shown here).

Figure 3 shows the same variables for a 6 month term. Also here the Krona interest rate is inside the rate-of-return band, except during months 36-38 (December 1989-February 1990) when it reaches the upper edge of the band. *Figure 4* shows the same variables for a 12 month term. Here we see that the Krona interest rate has been above the band on several occasions, in months 10-13 (October 1987-January 1988), and since month 35 (November 1989). Hence we find evidence that on these occasions there was a perceived risk of a devaluation within 12 months.

Figure 5 shows the same variables for 5 year bonds. Here we find evidence of a perceived devaluation risk throughout the period. The Krona interest rate was least

above the rate-of-return band in month 25 (January 1989). We note the dramatic rise away from the band since month 33 (September 1989).⁷

4.2 Capital Flows

The reasoning above is under the assumption of free international capital mobility. If the domestic interest rate happens to move outside the rate-of-return band for some term, large capital flows would immediately push the domestic interest rate inside the rate-of-return band, if the target zone is credible. If no big capital flows arise, in spite of the domestic interest rate being outside the rate-of-return band, this is evidence of a lack of credibility of the target zone.

Let us therefore check whether any large capital flows have been observed during periods when Krona interest rates have been outside their rate-of-return bands. Let us more specifically examine the amount of foreign exchange intervention done by Sveriges Riksbank. *Figure 6* shows monthly foreign exchange interventions (in billion Kronor) during the period February 1987-April 1990. Positive values denote foreign exchange inflows (purchases of foreign exchange). The Riksbank reports weekly and monthly net changes in foreign exchange reserves. These net changes in foreign exchange reserves, less government net foreign borrowing, we call *reported* foreign exchange interventions. They are plotted for each month in *Figure 6* as small triangles. These reported interventions do not, however, include changes in the Riksbank's positions in the forward foreign exchange market. (These positions are not included in the official definition of foreign exchange reserves, although they should of course be included in an economically meaningful definition of foreign exchange reserves.) Changes in the forward foreign exchange positions are reported separately, in *Sveriges Riksbank Quarterly Review*, with a three month lag. When these changes are added to the reported interventions, we get the *total*

⁷ The rate-of-return band (4a) and (4b) for the 60 month term presumes, if interest payments are yearly, that the exchange rate depreciates/appreciates gradually to the edge of the band in 5 years. Alternatively, we can assume that the exchange rate moves to the edge of the exchange rate band already in one year. This assumption causes a slightly wider rate-of-return band than the one given by (4a) and (4b). See appendix for details.

foreign exchange interventions, plotted as small circles with a connecting line.

Let us compare the total interventions in Figure 6 to the 12-month interest rate in Figure 4. The 12-month interest rate is outside its rate-of-return band from the end of month 10 (October 1987) to the end of month 13 (January 1988). During these months we do not see any large foreign exchange inflows in Figure 6; on the contrary we see some outflows. Hence we may conclude that this was indeed a period with a lack of credibility of the target zone on a 12 month horizon. We also see no large inflows in month 20 (August 1988) and month 22 (October 1988), when the interest rate is at the edge of its rate-of-return band. The 12-month interest rate again moves outside its rate-of-return band from the end of month 35 (November 1989) in which month we see a large foreign exchange *outflow*, indicating a definite lack of credibility of the target zone. Total capital flows are small in months 36-38 (December 1989-February 1990), although previously reported foreign exchange flows are positive. This does not contradict a continuing lack of credibility of the target zone. (At the time of writing this, in June 1990, changes in the Riksbank's forward foreign exchange positions have not been released for later months.)

4.3 Expected Exchange Rates

The expected exchange rate index is computed according to (5) and plotted as a function of the calendar month t and the horizon month τ in Figure 7. (The exchange rate index is measured in absolute units, rather than in percentage deviation from the benchmark value as in Figure 1.) The spot exchange rate is plotted for a zero horizon and can be read off the front edge of the box (the bottom of the box corresponds to an exchange rate index of 130, the lower edge of the exchange rate band).⁵ For each calendar month, the expected future exchange rate is plotted parallel to the left edge of the box, towards the back edge of the box which corresponds to a 60 month horizon ahead of the calendar month.

⁵ The actual exchange rate in month 37 (January 1990) is plotted (cf. footnote 6 above.)

We see in Figure 7 that the expected exchange rate 60 months ahead was the lowest (the expected future value of the Krona the highest) in month 25 (January 1989). The highest expected future exchange rate (lowest expected future value of the Krona) was in month 38 (February 1990). This is also illustrated in Figure 8, which shows the spot and expected future exchange rate plotted against the horizon, for both January 1989 (circles) and February 1990 (squares). (The horizontal line for the currency index at 134 shows the upper edge of the exchange rate band.)

In January 1989, the expected exchange rate 12 months ahead was well inside the band. The expected exchange rate 60 months ahead was outside the band, at 141.5, which corresponds to an expected depreciation of about 7 percent.

The situation in February 1990 was different. The expected exchange rate only 6 months ahead was at the edge of the band, the expected exchange rate 12 months ahead was well outside the band, and the expected exchange rate 60 months ahead was at 159.5, which corresponds to an expected depreciation of about 21 percent.

4.4 Expected Rates of Depreciation

In Figure 9 we have plotted the expected annualized rate of depreciation \bar{d}_t^{60} , using each month's expectation of the exchange rate 60 months later. We have also plotted the minimum and maximum rates of depreciation consistent with a credible exchange rate band, \underline{d}_t^{60} and \bar{d}_t^{60} . (These variables are of course by (7) nothing but the annualized interest rate differential between the 60-month Krona interest rate and the 60-month basket interest rate, and the maximum and minimum 60-month rates of return less the 60-month basket interest rate, cf. Figure 5.)

We see that the expected rate of depreciation reached a minimum, 1.6 percent, in month 25 (January 1989). From month 33 (September 1989) it rose to the highest level during the whole period, 4 percent, in months 38 and 39 (February and March 1990).

The excess of the expected rate of depreciation over the expected rate of depreciation within the band can be interpreted as the expected rate of *devaluation*. What is the

expected rate of depreciation within the band? We know that the expected rate of depreciation within the band is bounded by the minimum and maximum rates of depreciation. If the unconditional probability distribution of future exchange rates is symmetric, the expected depreciation within the band is for sufficiently long horizons given by depreciation to the middle of the band. This would correspond to the rate of depreciation given by the middle of the band between \underline{d}^{60} and \bar{d}^{60} in Figure 9. Since the band is narrow anyhow, let us simplify by setting the expected depreciation within the band equal to zero, and hence identify the expected rate of depreciation in Figure 9 with the expected rate of devaluation.⁹

If we then assume that devaluations are expected to occur regularly over time according to a Poisson process, we know from (8) that the expected rate of devaluation is equal to the product of the probability per unit of time of a devaluation and the size of a devaluation. Suppose for simplicity that a devaluation, if it occurs, is expected to equal 10 percent. Then we can interpret an expected rate of depreciation of 1.6 percent in Figure 9 in January 1989 as indicating expectations with a probability of devaluations of 16 percent per year ($\lambda = d_t^{60}/g = 1.6/10$), that is, an expected length of time to the next devaluation of almost 6 years.¹⁰ Similarly, when the expected rate of depreciation rose to 4 percent in February 1990, we can interpret this as indicating expectations with a probability of devaluations of 40 percent per year, that is, an expected length of time to the next devaluation of 2.5 years.

If we instead assume that a devaluation, if it occurs, is expected to be 20 percent rather than 10 percent, the probabilities above are halved and the expected length of time to the next devaluation is doubled.

⁹ See Svensson (1990b) for a rigorous derivation of the expected depreciation within the band for arbitrary horizons.

¹⁰ For a Poisson process with a probability λ per unit of time, the expected length of time to the next event is $1/\lambda$.

5. Conclusion

In conclusion, we have applied very simple tests of credibility to the Swedish target zone during February 1989 - April 1990, in a step-by-step fashion. *First*, under the assumption of sufficient international capital mobility and with the help of a simple arbitrage argument, we have tested target zone credibility by examining whether Krona interest rates fall outside rate-of-return bands for different terms. As an additional check, we have also examined the foreign exchange interventions at times when Krona interest rates have been outside their rate-of-return bands.

This simple test reveals that the Swedish target zone never had credibility within a 5 year horizon, and that it occasionally has lacked credibility within a 12 month horizon. The loss in credibility in the Winter of 1989-90 is particularly evident. In that period there is an indication of a perceived devaluation risk even within 6 months, since the 6-month Krona interest rate then reaches the edge of the 6-month rate-of-return band.

That the interest rates for shorter maturities than 6-months fall inside the bands does not, of course, imply that the target zone is necessarily credible for short horizons. The rate-of-return bands become very wide for short maturities. The probability of exchange rate movements to the edges of the band may be rather small, so the expected depreciation or appreciation in a short period for a credible band is much smaller. Therefore, short term interest rates may be well inside the rate-of-return bands as calculated here and still indicate devaluation risks. This is the case for the target zone models originated by Krugman (1988), where structural assumptions allow an explicit computation of the expected depreciation within a credible exchange rate band. In Svensson (1990b) such computations are used to specify interest rate bands for different maturities that are much narrower than the simple rate-of-return bands calculated here. The empirical results on the Swedish target zone in that paper for the period February 1986-October 1989 (hence, excluding the Winter 1989-90!) indicate statistically significant

(but small) devaluation risks for horizons down to 1 month. The first simple test used in the present paper has, however, the attractive feature of relying on a minimum of structural assumptions.

Second, under the additional assumption of uncovered interest rate parity, expected future exchange rates have been computed. Then target zone credibility have been illustrated in greater detail by plotting these expected future exchange rate in relation to the exchange rate band. The assumption also allows the lack of credibility of the target zone to be *quantified*: Expected Krona depreciation for different terms in excess of the maximum Krona depreciation compatible with the exchange rate band indicates expected positive devaluation for those terms. The expected devaluation within a 60 month horizon varies between 7 and 21 percent (the peak is observed in February 1990).

Third, by assuming that devaluations follow a Poisson process, the expected rate of devaluation of the Krona can be interpreted as the product of the probability per unit of time of a devaluation and the size of the devaluation. The expected rate of depreciation within a 60 month horizon has usually fluctuated between 1.6 and 3 percent. The peak is 4 percent in February 1990. For a 10 percent devaluation, that corresponds to a probability of devaluation of 40 percent per year, or an expected length of time to the next devaluation of 2.5 years.

These very simple tests of target zone credibility seem able to convey a fair amount of interesting information. It should be worthwhile to collect and compare similar information for longer time periods and for other target zones, both multilateral target zones like those in the Exchange Rate Mechanism within the European Monetary System and unilateral ones like those in the Nordic countries other than Denmark.

Interest rates for times to maturity between 1 and 5 years would provide more detailed information about expected future devaluations, for instance possible non-linearity. Of special interest is the issue of how efficient and liquid the world capital market is for debt instruments in different currencies for longer terms. For simplicity, we

have in this paper assumed that international investment for terms 1, 3, 6, 12 and 60 months is available in the important currencies in the Swedish currency basket. This assumption is surely all right for terms up to 12 months, probably all right for 60 months, but possibly doubtful for other terms above 12 months.

Appendix

For the 60-month interest rates, i_t^{*60} , let us assume that interest is paid yearly, in months $t+12$, $t+24$, $t+36$, $t+48$ and $t+60$. We then define the ex post rate of return, R_t^{60} , as fulfilling the equation

$$(A1) \quad 1 = i_t^{*60} \sum_{n=1}^5 \frac{S_{t+12n}/S_t}{(1+R_t^{60})^n} + \frac{S_{t+60}/S_t}{(1+R_t^{60})^5}.$$

Let us assume that the home currency appreciates (depreciates) gradually at an even rate until the exchange rate reaches the edge in month $t+60$. That is, $S_{t+12n} = S_t(\underline{S}/S_t)^{n/5}$, $n = 1, 2, \dots, 5$ ($S_{t+12n} = S_t(\bar{S}/S_t)^{n/5}$, $n = 1, 2, \dots, 5$). This still gives rise to lower and upper bounds according to (4a) and (4b).

Suppose we define the lower (upper) bound on the rate of return under the alternative assumption that the exchange rate appreciates (depreciates) to the lower (upper) edges of the exchange rate band already in one year and then stays there. That is, $S_{t+12n} = \underline{S}$, $n = 1, 2, \dots, 5$ ($S_{t+12n} = \bar{S}$, $n = 1, 2, \dots, 5$). Under this assumption the lower and upper bounds for the rate of return fulfill

$$(A2a) \quad 1 = \left[\frac{i_t^{*60}}{R_t^{60}} \left[1 - \frac{1}{(1+R_t^{60})^5} \right] + \frac{1}{(1+R_t^{60})^5} \right] \underline{S}/S \text{ and}$$

$$(A2b) \quad 1 = \left[\frac{i_t^{*60}}{R_t^{60}} \left[1 - \frac{1}{(1+R_t^{60})^5} \right] + \frac{1}{(1+R_t^{60})^5} \right] \bar{S}/S.$$

These expressions can be rewritten according to

$$(A3a) \quad \bar{R}_t^{60} \frac{(1 + \bar{R}_t^{60})^5 S/S - 1}{(1 + \bar{R}_t^{60})^5 - 1} = i_t^{*60} \text{ and}$$

$$(A3b) \quad R_t^{60} \frac{(1 + R_t^{60})^5 S/S - 1}{(1 + R_t^{60})^5 - 1} = i_t^{*60}.$$

These equations are easy to solve numerically.

The rate-of-return band arising from (A3a) and (A3b) is wider than the one resulting from (4a) and (4b), although the difference is small and hardly visible in Figure 5.

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Figure 1

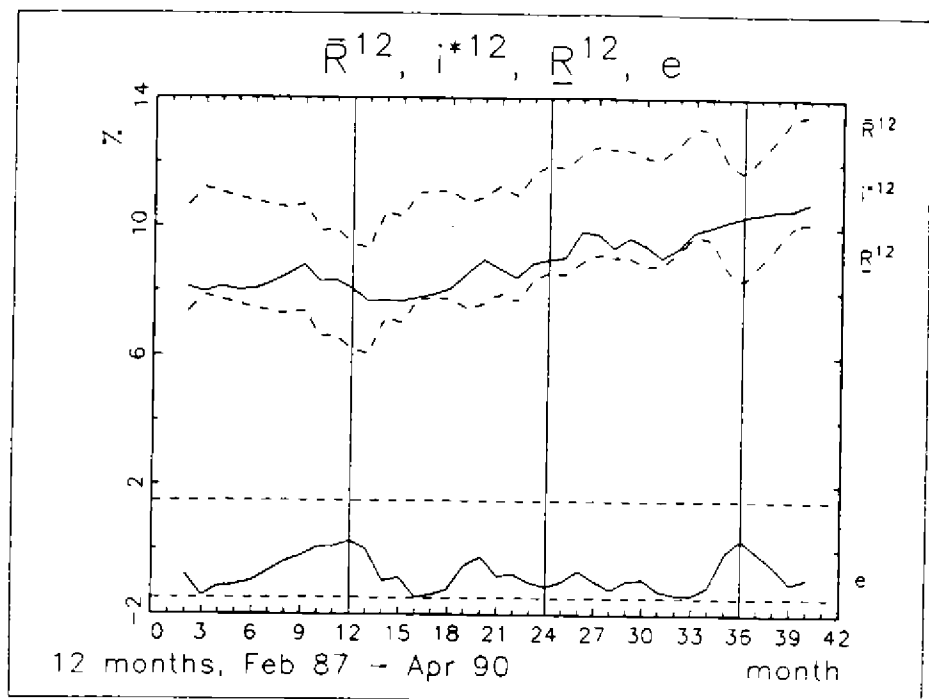


Figure 2

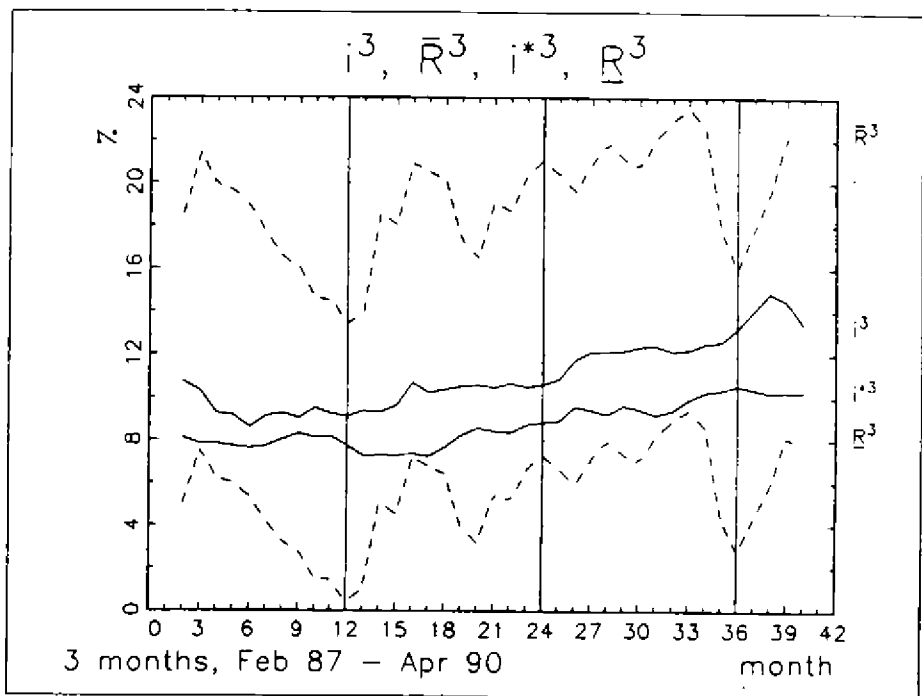


Figure 3

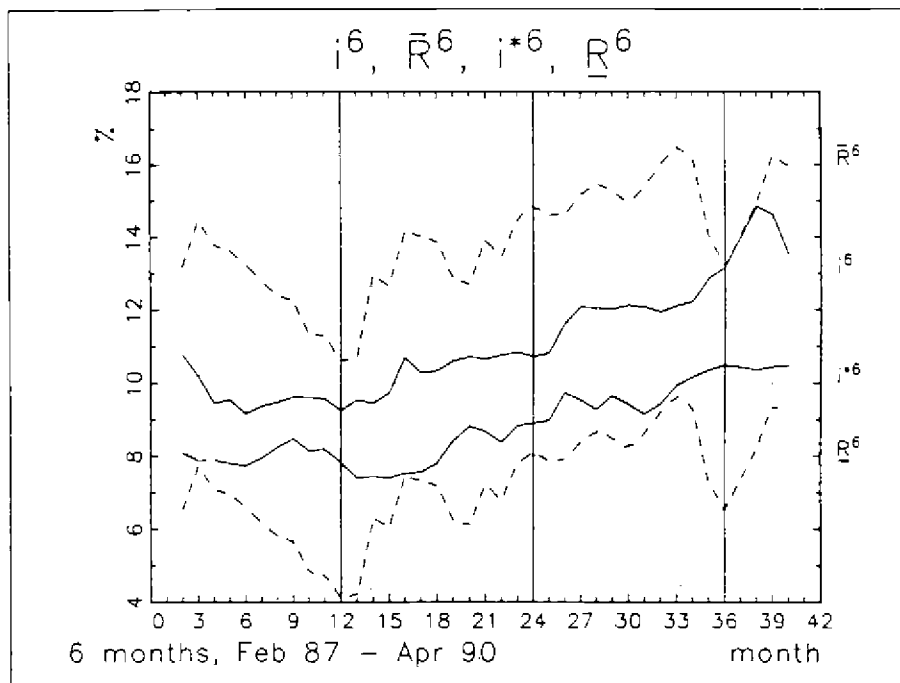


Figure 4

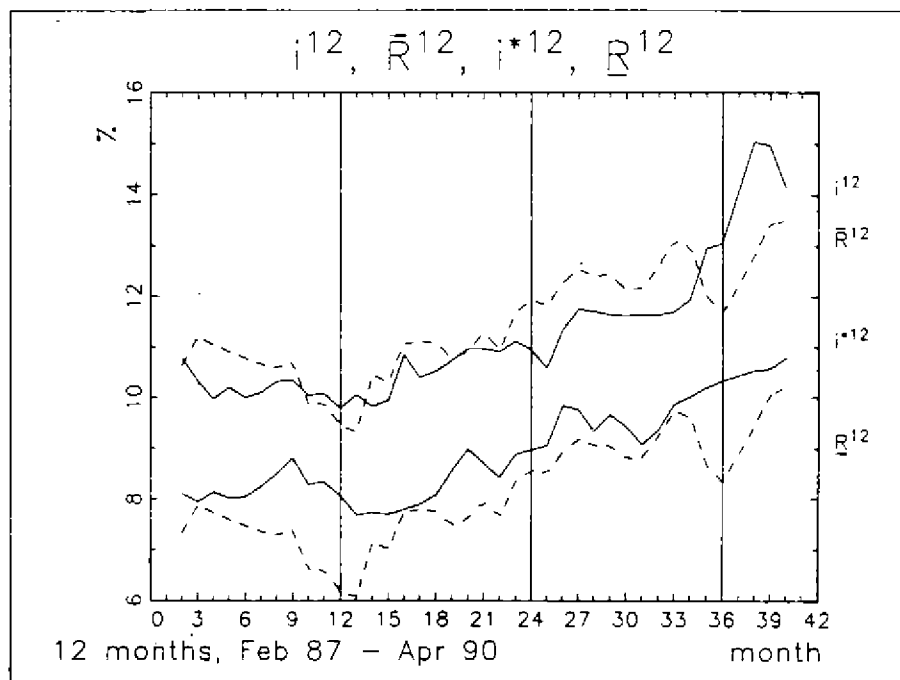


Figure 5

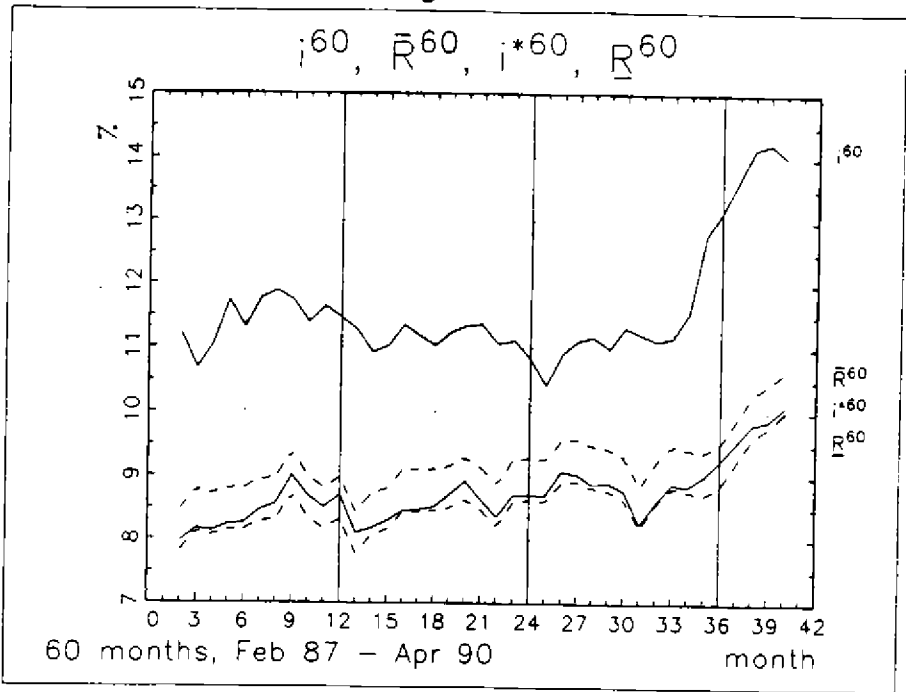


Figure 6

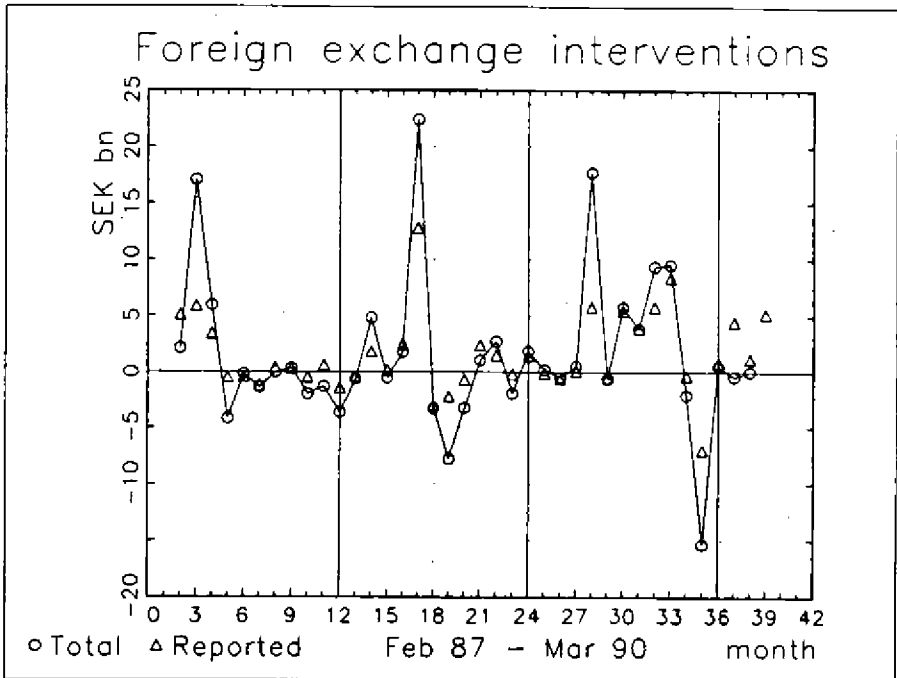
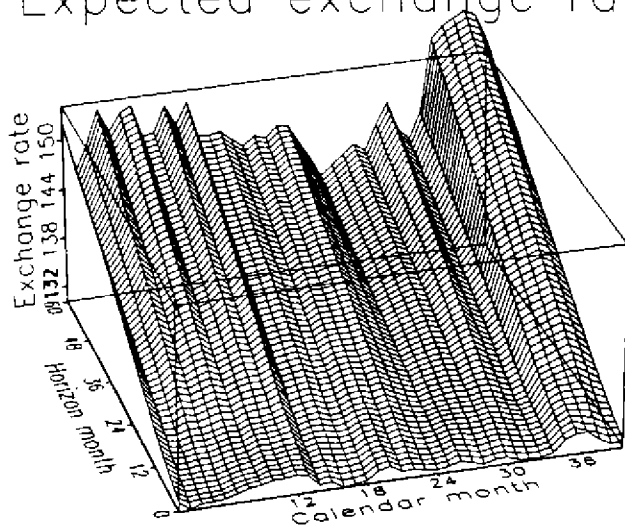


Figure 7

Expected exchange rate



Feb 1987 - Apr 90

Figure 8

Expected exchange rate

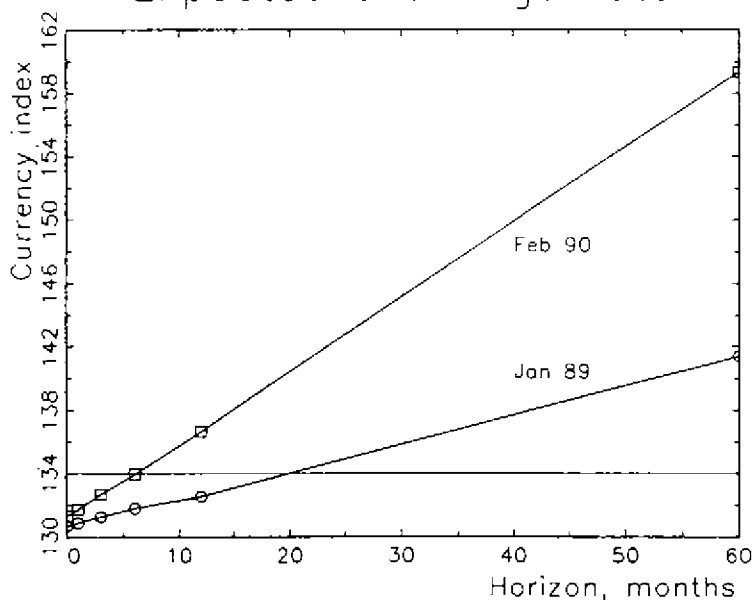


Figure 9

