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Testing the Basic Target Zone Model on Swedish Data*

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Abstract

The Swedish exchange rate band is studied using daily data on exchange rates and interest rate differentials for the 1980,s. Applying a number of diffferent statistical and econometrics techniques it is found that the first generation of target zone models cannot provide an adequate explanation of Swedish data. The main reasons are probably intra-marginal interventions by Sveriges Riksbank (The Swedish Central Bank) and time varying devaluation expectations.

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0. Introduction

The aim of this paper is to study some testable implications of the first generation of exchange rate target zone (TZ) models, using data for the Swedish Krona during the 1980's. This will hopefully establish some facts about the Swedish exchange rate and perhaps give some impetus to further refinements of the TZ models.

To meet these aims, we apply a number of straightforward, and when necessary, a few more sophisticated statistical/econometric techniques. In most cases, the results seem to refute the basic TZ models. There are two probable explanations to this. First, the basic TZ model assumes Central Bank interventions only at the target zone boundaries. In practice, Sveriges Riksbank (the Swedish Central Bank) intervenes intramarginally, which gives a different distribution of the exchange rate than predicted by the basic TZ model. Second, time varying devaluation expectations might cause a different correlation between the exchange rate and the interest rate differentials than predicted.

The rest of the paper is organized as follows. Section 1 summarizes the basic TZ model in order to extract the testable implications. Section 2 describes the data. Section 3 studies, among other things, the distributions and correlations of the exchange rate and interest rate differentials (for 1,3,6 and 12 months to maturity). Section 4 highlights the discrepancies between the model and data by first estimating the parameters in the TZ model and then performing a small Monte–Carlo experiment. Section 5 investigates whether the prediction power of an exchange rate equation is strengthened by taking into account non–linearities, which is an implication of the TZ model. Finally, section 6 summarizes our conclusions.

1. The basic exchange rate target zone model[1]

The starting point in this model is that exchange rates display many similarities with prices of assets traded on highly organized markets, for instance, shares. Similarly to this type of assets, foreign currencies can be traded with low transaction costs and storage is cheap. Evidently, this will give expectations about future exchange rates a key role in determining current rates. A standard way of formalizing this notion is

(1.1) $$s(t) = f(t) + \alpha dE[s(t)]/dt,$$

where $s(t)$ is the logarithm of the exchange rate at time t (the price of the foreign currency in terms of the own currency), $f(t)$ a fundamental determinant of the currency, α a positive parameter and E the expectations operator. The expression $dE[s(t)]/dt$ denotes $\lim_{\tau \to 0^+}[Es(t+\tau) - s(t)]/\tau$. Disregarding the discussion about the exact nature of $f(t)$ and why $\alpha \neq 0$, we follow Krugman [1988] and let

(1.2a) $$f(t) = m(t) + v(t).$$

In (1.2a) $m(t)$ can be thought of as the logarithm of the money stock, which is controlled by the monetary authority, and $v(t)$ as the logarithm of the velocity which follows a random walk (Brownian motion)

(1.2b) $$dv(t) = \sigma dz.$$

(We diregard the case with a non–zero drift in $v(t)$). In (1.2b) σ is a constant instantaneous standard deviation and z a standard Wiener process, with $E(dz)=0$ and $E[(dz)^2]=dt$. Hence, $E(dv)=0$, $E[(dv)^2]=\sigma^2 dt$ and $E[v(t)|I(0)]=v(0)$ where $I(t)$ is the information set at time t. The random walk assumption is very convenient insofar as it lets us solve the model analytically.

Assume that the monetary authority wants to keep the exchange rate within a certain symmetric band $[-\bar{s},\bar{s}]$ around zero. This can be achieved by defending a

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[1] This section draws on Krugman [1991], Svensson [1991a] and Svensson [1990].

corresponding band for the fundamental $f(t)$. Hence, the band $[-\bar{f},\bar{f}]$ is defended by the following policy rule:

(1.3) $$dm = dL - d\bar{U}, \text{ where } \begin{cases} dL>0 & \text{only if } f=-\bar{f} \\ d\bar{U}>0 & \text{only if } f=\bar{f} \end{cases},$$

and where dL and $d\bar{U}$ are infinitesimal interventions. Furthermore, it is assumed that this policy is credible, that is, that the agents are sure about that no changes will take place in the policy rule. This rules out, among other things, devaluation expectations.

The task here is to find a function $g[f(t)]$ describing the evolution of the exchange rate. Using (1.1) and applying Ito's lemma, we have that $g[f(t)]$ must fulfill the second order differential equation

(1.4) $$g[f(t)] = f(t) + \tfrac{1}{2}a\frac{d^2g[f(t)]}{df^2}\sigma^2.$$

The general solution to (1.4) is

(1.5) $$g[f(t)] = f(t) - 2A\sinh[\lambda f(t)],$$

where A remains to be determined.[2] In a target zone A can be determined from the "smooth pasting" condition, which requires that $dg(\bar{f})/df=0$. This gives the target zone exchange rate function

(1.6a) $$g[f(t)] = f(t) - \sinh[\lambda f(t)]/[\lambda\cosh(\lambda\bar{f})]$$

where

(1.6b) $$\lambda = [2/(a\sigma^2)]^{\frac{1}{2}}.$$

In order for the monetary authority to determine a suitable symmetric band around zero for the fundamental $[-\bar{f},\bar{f}]$ which corresponds to the desired exchange rate band $[-\bar{s},\bar{s}]$, the following equation must be solved for $\bar{f}$:

(1.7) $$\bar{s} = \bar{f} - \tanh(\lambda\bar{f})/\lambda.$$

In an exchange rate regime with free float, A=0 and $s[f(t)] = f(t)$.

Diagram 1.1 illustrates the target zone exchange rate function and the free float

[2] *sinh*, *cosh* and *tanh* denotes the hyperbolic sine, cosine and tangent functions, respectively.

exchange rate function for the parameter values $\alpha=3$, $\sigma=0.1$ and $[-\bar{s},\bar{s}]=[-0.015,0.015]$. These parameter values will be used throughout this section. Note that the slope $dg[f(t)]/df$ is always less than unity ("honeymoon effect") and that it approaches zero at the boundaries ("smooth pasting"). The function is non–linear (S–shaped).

Using a result in Harrison [1985], we note that the unconditional probability density function for the fundamental is uniform,

$$p^f(f) = 1/(2\bar{f}). \tag{1.8}$$

Now, we have by the "change–of–variable–in–density–function–lemma"[3] the unconditional density function for the exchange rate

$$p^s(s) = p^f[g^{-1}(s)]\left|\frac{d[g^{-1}(s)]}{ds}\right| \quad s\in(-\bar{s},\bar{s}), \tag{1.9}$$

where $g^{-1}(s)$ is the inverse of (1.6). Even though $g^{-1}(s)$ is only defined implicitly, the $p^s(s)$ function can easily be calculated numerically. The result is displayed in diagram 1.2. The density function is U–shaped, which is an effect of the assumption that the interventions only takes place at the boundaries. This implies that the exchange rate should have higher even moments (for instance, unconditional standard deviation) than a uniformly distributed variable.

Applying Ito's lemma on the exchange rate function $g[f(t)]$, we have the instantaneous (conditional) standard deviation of the exchange rate

$$\sigma^s(s) = \frac{dg[g^{-1}(s)]}{df}\sigma, \tag{1.10}$$

which is shaped like an inverted U. This is illustrated in diagram 1.3.

Let $i(t)$ be the endogenous domestic and $i^*(t)$ the exogenous foreign instantaneous interest rates, and $\delta(t) = i(t) - i^*(t)$ the instantaneous interest rate differential. Assuming uncovered interest parity, we have $\delta(t) = dEs[f(t)]/dt$, why the interest rate differential is a function of f only. Using (1.1), this equals

[3]See, for instance, Spanos [1986].

(1.11) $$\delta[f(t)] = \frac{g[f(t)] - f(t)}{a}.$$

Since $dg/df<1$ we have $d\delta/df<0$ and the instantaneous interest rate differential is decreasing in the fundamental and hence in the exchange rate. But, it is probably more rewarding to study bonds with finite term. In order to do that we follow Svensson[1990] and use an approximate form of uncovered interest parity (expressed as annualized interest rates)

(1.12) $$\delta[f(t),\tau] = \frac{Es[f(t+\tau)|I(t)] - s[f(t)]}{\tau}, \qquad \tau>0$$

where τ is the term measured in years (for instance, a 3 month bond has τ=1/4). The first step in calculating $\delta[f(t),\tau]$ is to find a function for the expected exchange rate at $t+\tau$

$$h[f(t),\tau] = Es[f(t+\tau)|I(t)].$$

Svensson[1990] shows that this function must fulfill

(1.13a) $$\frac{dh[f(t),\tau]}{d\tau} = \tfrac{1}{2}\sigma^2 \frac{d^2h[f(t),\tau]}{df^2}, \quad f\epsilon[-\bar{f},\bar{f}],\ \tau>0.$$

with initial values given by

(1.13b) $$h[f(t),0] = g[f(t)]$$

and the boundary conditions

(1.13c) $$dh[-\bar{f},\tau]/df = dh[\bar{f},\tau]/df = 0.$$

This is a parabolic partial differential equation, which can be solved numerically or with Fourier methods.[4]

Diagram 1.4 shows the interest rate differential as function of the exchange rate for $\tau = \{0,1/12,1/4,1/2,1\}$. All curves have the same shape with a negative relation between the interest rate differential and the exchange rate, but for longer terms the interest rate differential is less responsive to the exchange rate. Another implication of the diagram is that the interest rate differential yield curve should have a negative slope in the upper half of the band, et vice versa in the lower half. We can calculate the unconditional probability

[4]Svensson [1990] describes an algorithm based on Gerald and Wheatley [1989] and also obtaines an analytical solution using Fourier methods. Another good description of numerical solutions is found in Flannery et al [1986].

density functions for different terms. This is illustrated in diagram 1.5. For finite terms the probability density functions are U–shaped – much like the exchange rate – and for longer terms they are more compressed.[5] Consequently, the longer terms should have lower even moments. Finally, the instantaneous (conditional) standard deviation of the interest rate differential is illustrated in diagram 1.6. For finite terms, the standard deviation as function of the interest rate differential is shaped like an inverted U and the standard deviation decreases with maturities.

The Krugman target zone model has a number of testable implications. Some of the more important are:

(*i*) The exchange rate is a non–linear function (S–shaped) of the fundamental and the slope is always less than one ("honeymoon effect").

(*ii*) The exchange rate distribution is U–shaped.

(*iii*) The conditional standard deviation of the exchange rate as a function of the exchange rate is shaped like an inverted U.

(*iv*) The relation between the interest rate differential and the exchange rate is negative, and weaker for longer maturities. In theory, this is a deterministic relationship since there is only one state variable (f) in the model.

(*v*) The interest rate differential distribution is U–shaped. For longer terms it is more compressed.

(*vi*) The conditional standard deviation of the interest rate differential, as a function of the interest rate differential, is shaped like an inverted U.

The rest of the paper is an attempt to evaluate these predictions using data for the Swedish Krona during the 1980's.

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[5]Svensson [1990] discusses the qualitative difference between the finite–term and the instantaneous interest rate differential.

2. Description of the data

Most of the interest and exchange rate data were obtained from the Bank of International Settlements (BIS) database. The data are daily and cover the period 82:01:01 – 90:11:15 (year:month:day). Exchange rates are recorded at the daily official fixing. Interest rates are annualized simple bid rates on Euro–currency deposits carrying a fixed maturity of 1, 3, 6, and 12 months respectively at around 10 am Swiss time. However, Euro–deposit rates denominated in Finnish markka were not available at the BIS and were instead obtained from Sveriges Riksbank.

The exchange rates of the currencies in the Swedish currency basket were recalculated in terms of the Swedish currency index. The interest rates on deposits denominated in basket currency were constructed from the Euro–deposit rates according to the currencies' effective weights in the Swedish currency basket. The calculation of the effective weights are described in Appendix 1. However, we have been forced to make a small approximation due to the fact that Euro–deposit rates in Finnish markka were only available for the period 85:02:08 – 90:11:15 and hence not included in our basket deposit rate before that period. An additional approximation is that deposit rates on Spanish Pesetas with a maturity of 12–months were only included in the corresponding basket deposit rate for the period 85:04:30 – 90:11:15. Of course, for these periods with incomplete data, the weights of the remaing countries have been scaled accordingly to sum to unity. The partial exclusion of the Spanish Pesetas is of only marginal importance since the effective weight of the Pesetas is very low (around 1%). The partial exclusion of the Finnish Markka is possibly more problematic since the effective weight is fairly high (around 6%). On the other hand, it can be argued that this lack of data for the Markka simply reflects the lack of a developed Euro–deposit market for the Markka in the early 1980's. In that case, exclusion of the Markka contributes to a better representation of the actual investment possibilities that existed at that time.

Euro–deposits are quoted as annualized simple interest rates on an actual/360 basis, that is, with the actual number of days from settlement to redemption of the deposits and with a 360 day year. The interest rates on deposits denominated in the basket currency and Swedish kronor were compounded with a 365 day year in order to make the interest rate data more suitable for the testing of the basic target zone model. However, we have not purged the data from the effects of weekends and holidays at the redemption of the deposits.

The interest rate differentials between Euro–deposits in Swedish kronor and basket currency with the same maturity should be relatively free of political, credit, settlement and liquidity risk premia. However, it's possible or even plausible that the Swedish capital controls, which were progressively eased and finally abolished in July 1989, affected the interest rates on Euro–deposits denominated in Swedish kronor. An alternative would have been to use the domestic interest rates on Banker's certificate of deposits for the period January 1982 – June 1983, and treasury bills for the period July 1983 – November 1990. However, the interest rate differentials between these domestic assets and the basket Euro–deposits are definitely affected by the different kinds of risk premia mentioned above. In addition, the data on domestic interest rates are closing rates at 3.30 pm and thus not completely comparable with the Euro–deposit rates available at the BIS.

3. Testing the implications for distributions and correlations

This section is devoted to studying whether the testable implications of the basic exchange rate target zone (TZ) model as described in section 1 hold for daily data for Sweden during 82:01:01–90:11:15. This is done by plotting and computing a number of statistics of the exchange rate and interest rate differentials for 1,3,6 and 12 months time to maturity.

Diagram 3.1 shows the the Swedish currency index, which is a trade weighted average of the Swedish exchange rate against 15 other currencies (a detailed description is found in Appendix 1), since its start 77:08:29. The index can be interpreted as an exchange rate correspondning to $s(t)$ in section 1. Hence, a higher index indicates a weaker Krona. The central parity was first set at 100. At the devaluation 81:09:14 it was changed to 111 and at the second devaluation 82:10:08 to 132. The exchange rate band was officially declared to be ±1.5% in 85:06:27. For the earlier period, the Riksbank claims to have been defending an unofficial band of ±2.25%. The exchange rate band is marked by dashed lines in the diagram.

Diagram 3.2 shows the currency index as a percentage deviation from central parity (which will henceforth be called just the exchange rate) and the annualized effective interest rate differential for the period 82:01:01–90:11:15. In order to save space, only the interest rate differential for 3 months to maturity is plotted in this and subsequent graphs. In general, the various interest rate differentials look very similar. As before, the exchange rate band is marked by dashed lines in the diagram. A few things are worth noting in the diagram. First, the interest rate differential has almost always been positive. Second, there are periods when the exchange rate and the interest rate differential seems to move in opposite directions as predicted by the basic TZ model, but the opposite is not uncommon either. The latter is most clearly seen at those instances when the exchange rate increases towards the upper boundary. Third, during the period summer 1985 until late 1989, the exchange rate was in the lower (stronger) half of the band almost all the time. Fourth, for at least the second half of the sample there is a tendency for the exchange rate to increase att the end of the year.

Diagrams 3.3a–b show scatter plots of the exchange rate and the interest rate differential (one month to maturity) for the two sub–periods before and after the official announcement of the band (85:06:27). Compared with the theoretical relation stated in prediction (iv) in section 1 and illustrated in diagram 1.4, the lack of a simple pattern is disturbing for the basic TZ model with a perfectly credible exchange rate band. In fact, according to tables 3.1–3.5 the correlation between the exchange rate and the interest rate differential is positive and, if anything, increasing with maturity. This clearly contradicts the theoretical predictions and will also rule out simple models of devaluation expectations, such as a constant expected devaluation. These results could be contrasted to the negative correlations found by Svensson [1990] for the period February 1986 to October 1989. That period was characterized by fairly small and stable interest rate differentials, as was illustrated in diagram 3.2. In fact, most of the observations in the upper right quadrant of diagram 3.3b are for the period after late 1989. One interpretation is that February 1986 to October 1989 was a period with fairly high credibility of the Swedish exchange rate band. That is, it seems as if there were at most very modest expecatations of a realignment of the the Swedish Krona during this period.

Given that the exchange rate averages for the two sub samples were just slightly below parity, the average interest rate differentials, found in tables 3.2–3.5, seems also to be somewhat too high to be consistent with a credible band. This is most obvious for the 12 month interest rate differential. But, unlike Flood, Rose and Mathieson [1990] who studied EMS data, we find only weak evidence of non–stationarity of the exchange rate and interest rate differential, since the unit root can be rejected in most cases in tables 3.1–3.5.

Diagrams 3.4a–b show the frequency distributions of the exchange rate for the two sub–periods before and after 85:06:27. According to theory, as stated in prediction (ii) in section and illustrated by diagram 1.2, these should be U–shaped. In practice, they are all but U–shaped. This is consistent with the findings in Flood, Rose and Mathieson [1990] for EMS data. Moreover, according to table 3.2 the exchange rate shows no excess kurtosis at all, rather the opposite. In terms of the model in section 1, this implies that the fundamental (1.2b) process is mean reverting. This could, for instance, be explained by intramarginal interventions. It can also be noted from table 3.1 that during the second sub–period the exchange rate is clearly skewed to the left of its mean. This could possibly be explained by an implicit band in the lower half of the band during the period late 1985 to autumn 1989, followed by a period with markedly higher exchange rates.

Diagrams 3.4c–d show the frequency distributions of the interest rate differential (1 month) for the two sub–periods. Prediction (v) and diagram 1.5, states that these distributions should be U–shaped too. As before, this is not the case, even if tables 3.2–3.5 shows that all interest rate differentials for all periods are leptokurtic (fat tails). But, almost all are also skewed to the left. This is tantamount to a clustering of observations at relatively low interest rate differentials combined with a long tail of observations at much higher differentials. The latter could possibly reflect short periods of high devaluation expectations.

Another theoretical implication of diagram 1.5 is that the unconditional standard deviation of the interest rate differential should decrease with the maturity. According to table 3.6 this is indeed the case, at least when comparing 6 and 12 months with 1 month.

Table 3.1 shows a considerable conditional heteroskedasticity of the exchange rate, but plots of the conditional standard deviations for the two subperiods in diagrams 3.5a–b reveal no clear pattern. But, the evidence of a shape like an inverted U, as predicted in (iii) in section 1 and illustrated in diagram 1.2, is very weak. These observations carry over to the interest rate differentials (prediction (vi) in section 1 and illustrated in diagram 1.6) of different maturities in diagrams 3.5c–d and tables 3.2–3.5.

Taken together, these facts implicates that prediction (ii)–(vi) in section 1 are refuted. Hence, the basic exchange rate target zone model is far from being a good description of the Swedish exchange rate band. First of all, the interest rate differentials suggest that the Swedish exchange rate band has not always been credible. Second, the distribution of the exchange rate suggests that fundamentals are mean reverting. Furthermore, there could very well have existed implicit bands withinh the official exchange rate band during this sample.

4. Estimating the basic TZ model

This section provides an additional way of assessing the basic TZ model. It describes an attempt to estimate the parameters in the basic exchange rate target zone model for Sweden 85:06:27–90:11:15 using a simulated moments estimator (SME). The fit of the model is then investigated by using the estimated parameter values in a small Monte–Carlo experiment.

The basic TZ model is estimated using daily Swedish exchange rate data for the period 85:06:27–90:11:15. The choice of the SME method stems from two facts. First, we have only vague ideas of what the fundamentals actually are and hence this variable is in practice non–observable. Second, the model is such that it is difficult (if not impossible) to arrive at analytical expressions for the moments of the exchange rate. The use of SME in estimating target zone models originates from Spencer [1990], and our approach is similar even if we use a different algorithm.

Assuming away any drift component, which is very plausible given the behaviour of the Swedish exchange rate 85:06:27–90:11:15, the task is to estimate the parameters $[\alpha,\sigma,\bar{f}]$ in the model summarized by (1.6a–b), given the assumption that the fundamental follows (1.2–b) and (1.3) and the knowledge that the exchange rate band $[-\bar{s},\bar{s}]$ was ±1.5%. But, given $[\alpha,\sigma,\bar{s}]$, the boundary for fundamentals $\bar{f}$ is defined implicitly by (1.7). Hence, what remains to estimate is just α and σ. The SME for $[\alpha,\sigma]$ is given by minimizing

$$G(\alpha,\sigma)'V\,G(\alpha,\sigma), \tag{4.1a}$$

where

(4.1b) $$G(a,\sigma) = 1/T^* \sum_{t=1}^{T^*} M_t^* - 1/T \sum_{t=1}^{T} M_t(a,\sigma).$$

In (4.1a) W is a weight matrix and $G()$ is a vector of differences between empirical and simulated moments defined in (4.1b). In (4.1b) M_t are vectors of moment generating functions with T denoting the sample size. A symbol marked with an asterix (*) refers to empirical data, without an asterix it refers to simulated data. In the estimations, we have used

(4.2a) $$M_t = \begin{pmatrix} [s_t\text{-mean}(s)]^2 \\ [\Delta s_t\text{-mean}(\Delta s)\ ] \end{pmatrix}, \quad M_t^* = \begin{pmatrix} [s_t^*\text{-mean}(s^*)]^2 \\ [\Delta s_t^*\text{-mean}(\Delta s^*)\ ]^2 \end{pmatrix},$$

and

(4.2b) $$W = \begin{bmatrix} 1 & 0 \\ 0 & \text{variance}(s^*)^2/\text{variance}(\Delta s^*)^2 \end{bmatrix}.$$

In (4.2), Δ is the difference operator. Hence, the loss function in (4.1) is a weighted average of the squared difference between empirical and simulated variance of the exchange rate and the change in the exchange rate. The weights eliminate the effect of the different scales of $(s^*)^2$ and $(\Delta s^*)^2$. The model is exactly identified since there are two parameters to estimate and we use two moments in the loss function.[6]

The algorithm for the SME used is as follows.

(a) Generate a series $\{\Delta z_t\} = \epsilon_t\sqrt{\Delta t}$, where ϵ_t is a drawn from a standard normal distribution and Δt is the share of a year of the sampling interval. In this way, the yearly sum of $\{\Delta z_t\}$ has unity variance. In the simulations $\Delta t = 1/1500$, which corresponds to 6 observation per trading day (250 per year).

(b) Generate a series $\{f_t\}$ from

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[6]Duffie and Singleton [1989] investigates the SME in detail. They show, among other things, that effeciency can be gained by using the inverse of the covariance matrix of M^* as the weight matrix and how to obtain asymptotic standard errors of the estimates. We defer these extensions to future work.

$$
(4.3) \qquad f_{t+1} = \begin{cases} \bar{f} - (f_t + \sigma\Delta z_{t+1} - \bar{f}) & \text{if } f_t + \sigma\Delta z_{t+1} \geq \bar{f} \\ -\bar{f} - (f_t + \sigma\Delta z_{t+1} + \bar{f}) & \text{if } f_t + \sigma\Delta z_{t+1} \leq -\bar{f} \\ f_t + \sigma\Delta z_{t+1} & \text{otherwise.} \end{cases}
$$

By this reflection of the fundamental in case of hitting a boundary, the asymptotic probability distribution becomes uniform.

(c) For each point $[a_i,\sigma_j]$ in a grid of $[a,\sigma]$– values, compute $\bar{f}_{ij}$ from (1.7) and generate an exchange rate series $\{s_t\}$ by equation (1.6a–b) (multiplied with 100). Pick out each 6th observation of $\{s_t\}$ in order to get daily observations and and calculate $\{\Delta s_t\}$ from these sampled observations.

(d) Repeat (a)–(c) 10 times and calculate the value of (4.1) for each point in the grid of $[a,\sigma]$–values, with $1/T\sum_{t=1}^{T} I_s(a,\sigma)$ calculated as the average over the 10 repetitions. Choose the point $[a_i,\sigma_j]$ that gives the lowest value of (4.1).

The initial guess and also the midpoint of the first $[a,\sigma]$–grid was [0.7,0.0719].[7] In practice, a number of repeated trials have been necessary to locate the parameter range of interest. In the final estimation, the ranges $a \epsilon [0.015,0.56]$ and $\sigma \epsilon [0.001,0.057]$, each with 60 subdivisions, were used. This means that 36000 exchange rate series were generated, each with 6*1123 elements (empirical data has 1123 observations). The estimated parameter

[7]According to table 3.1 the daily variance of the exchange rate is 0.273. Since data in table 3.1 were expressed as percentages, this corresponds to 0.2732E–4 in terms of the model which is the yearly variance of the exchange rate (S) times the sampling interval as a fraction of a year. The latter is approximately 1/250 for daily data. Hence, the yearly variance of the exchange rate should be 0.273E–4*250 = 0.683E–2. Furthermore, according to Svensson [1991a], the standard deviation of s, which has the dimension sqrt(year), should be around 15% higher than for the fundamental f. Hence, we use σ = sqrt(0.683E–2)/1.15 = 0.0719 as a first guess. For a, the usual interpretation is that it correspond to the (negative of) the semi–elasticity of money demand with respect to the interest rate and it has the dimension year. Markowski [1988] estimates the short run semi–elasticity of demand for Swedish notes and coins to be –0.7, which will be used as a first guess. Of course, the interpretation of this short run estimate is problematic. In a not too different context and partly based on similar reasoning Flood,Rose and Mathieson [1990] choose to investigate the range $a \epsilon [0.1,1]$, which seems reasonable.

values are a=0.24933 and σ=0.00860, which gives $\bar{J}$=0.01804. It can be shown that the loss function (4.1a) is sensitive to the choice of σ. On the other hand, the loss function is very flat in the a dimension, given that σ is around its optimal level. This implicates that σ is estimated with higher precision than a.

The fit of the estimated model is analyzed by means of a small Monte–Carlo experiment. Using the estimated parameters, 100 samples of the exchange rate were generated and for each of these a number of statistics were computed. Table 4.1 shows the average of these 100 samples. The empirical counterparts for 85:06:27–90:11:15, found in the second column, are reprinted from table 3.1. The last column shows the percentage of the simulated moments that was below the corresponding empirical moment.

First, it is worth noting that the unconditional standard deviation, which is part of the loss function (4.1a), is well matched. Second, the simulated conditional standard deviation is always lower than the empirical counterpart. Third, since the exchange rate actually was below the lower boundary a few times, the simulated minimum is never lower than the empirical. Fourth, the simulations show much less skewness (to the left) than the empirical exchange rate, but the evidence for the kurtosis is not so clear. Fifth, the simulations are less heteroskedastic and finally, the rejection of the non–stationarity is much weaker than in data.

Compared with the results of Spencer [1990] which are for FFr/DM, we estimate a higher σ (0.0086 versus 0.0017) and a lower a (0.249 versus 2.725). In the simulations we find much less skewness and more heteroskedasticity than Spencer [1990]. The former is probably explained by the fact that we have set the drift term to zero, while the latter is somewhat surprising since a lower a would tend to make the exchange rate equation more linear, and hence less heteroskedastic (the curve in diagram 1.3 would be flatter). The different methods of testing for heteroskedasticity might be an explanation.

All in all, it seems as if the empirical exchange rate is more densely distributed but more skewed to the left than the simulations. This could possibly be explained by the combination of an implicit band in the lower half of the official band during much of the sample and intramarginal interventions. Furthermore, the empirical exchange rate has more of conditional heteroskedasticity and is therefore less predictable – even if the overall variability is about the same as in the simulations. This is consistent with the view that even if the Riksbank has kept the exchange rate from moving too close to the official boundaries, especially the upper boundary, there is a lot more jumps in the exchange rate than would be predicted by the rather smooth regulated Brownian motion with a standard deviation as low as the estimated.

5. Testing for non–linearities

This section is a non–parametric investigation of the existence of non–linearities in the Swedish exchange rate during 85:06:27–90:11:15, that is, of the first part of prediction (i) in section 1.

The basic exchange rate target zone equation, as illustrated in diagram 1.1, is a non–linear (S–shaped) function of the fundamental. This has the implication that the expected exchange rate, which is obtained by solving the partial differential equation (1.13a–c), is a non–linear function of the current exchange rate. By the uncovered interest parity condition (1.12), we have that this non–linear relation carries over to the interest rate differential, which is illustrated in diagram 1.4. Furthermore, the degree of non–linearity is more pronounced for shorter forecasting horizons (time to maturity) and close to the boundaries of the exchange rate band.

One way of testing for non–linearities is to make use of a locally weighted regression (LWR) and to compare its prediction errors with those of more conventional linear methods. If it turns out that the LWR produces lower prediction errors, then this ought to be a superior forecasting method and a partial proof of the existence of non–linearities.

The idea of the LWR is the following. Assume that we believe that the exchange rate is well predicted by $s_t = k(x_t)$, where k is some unknown smooth function and x_t a vector of variables, for instance, lags of s_t. Then, for each point x^*, which in practice is for each x_t since it is highly unlikely that x_t vectors are identical, estimate a parameter vector β^* using weighted least squares. The weights of the observations $\{...,x_{t-1},x_t,x_{t+1},...\}$ in this regression is a tricube function of the euclidean distance of the respective observation and x^*. The predicted value of s at x^* is then formed as $x^*\beta^*$. This is repeated for each point x^*. This could be regarded as a series of linear approximations of the function k. A parameter ξ $(0<\xi\leq1)$ determines the smoothness of this approximation. Effectively, observations too far away gets a zero weight and the value of ξ governs how far this "too far" is. With $\xi=1$ all but one observation in the sample would have a non–zero weight. We are agnostic about the best value of ξ so several values will be tried. A detailed description of the LWR is found in Cleveland, Devlin and Grosse [1988].

The non–linearity in the Swedish exchange rate for the period 85:06:27–90:11:15 has been studied by comparing the standard errors of three different forecasting models

(5.1a) $$s_t = \text{LWR}(s_{\tau-1},s_{\tau-2},s_{\tau-3},s_{\tau-4},s_{\tau-5}) + u_{1t},$$

(5.1b) $$s_t = \psi_0 + \psi_1 s_{\tau-1} + u_{2t},$$

(5.1c) $$s_t = \omega_0 + \omega_1 s_{\tau-1} + \omega_2 s_{\tau-2} + \omega_3 s_{\tau-3} + \omega_4 s_{\tau-4} + \omega_5 s_{\tau-5} + u_{3t}.$$

In (5.1a–c), $\tau=t$ for the in–sample comparison, but $\tau=t-1$ for the one–step–ahead out–of sample comparison, $\tau=t-10$ for the 10–steps–ahead out–of sample comparison and $\tau=t-30$ for the 30–steps–ahead out–of sample comparison. Of course, (5.1b–c) are AR(1) and AR(5) processes, respectively. The LWR has been computed using three different values of ξ, namely 0.3,0.5 and 0.9. The results, in the form of standard errors of the predictions, are reported in table 5.1a–d.

According to table 5.1a, it seems as if the best LWR clearly out–performs both the AR(1) and the AR(5) in–sample. In the out–of–sample prediction the LWR fares worse.

These forecasts have been made for three different periods: for the last 100 observations (summer and autumn 1990 when the exchange rate was in the middle of the band), for 1989 (when the exchange rate was close to the lower boundary much of the time) and for the entire sample 85:06:27–90:11:15. The reason is that the basic TZ model exhibits most of the non–linearities close to the boundaries and is fairly linear in the middle of the band. According to tables 5.1b–d, it is only on the 1–day horizon that the LWR can match the linear methods. This is most pronounced during the 1989, when the exchange rate was close to the lower boundary. Interestingly, these two observations are supported by theory.

The evidence of non–linearities in the best univariate forecasting equation for the Swedish exchange rate is weak. This is consistent with the findings of Diebold and Nason [1990], who use the LWR method on ten different currencies – although not the SEK. They found that the LWR performs better than a random walk in–sample but actually worse out–of–sample. Flood, Rose and Mathieson [1990] find in–sample evidence of non–linearities in EMS data using a parametric approach, but fail to find any superior out–of–sample prediction power of non–linear specifications.

It is only at very short forecasting horizons and during periods when the exchange rate is close to a boundary as there seem to be a gain by using a non–linear method. Hence, the support for prediction (i) in section is at best weak. Now, any target zone model with known interventions at the boundaries will exhibit some non–linearities close to the boundaries. But, if intramarginal interventions also take place, the exchange rate will tend to be mean reverting. This means that those non–linearities that may be present will only show up occasionally and hence will be hard to detect quantatively.

6. Conclusions

This paper shows that the first generation of target zone models is far from being a good description of the Swedish exchange rate band. Our results seems to refute the models in most cases.

First, the frequency distribution of the exchange rate is not U–shaped as predicted by the basic target zone models. This could be explained by the fact that Sveriges Riksbank frequently make intra–marginal interventions to defend the exchange rate band. This is illustrated in diagram 5.1, which shows the relative number of days with interventions on the spot exchange market across the Swedish exchange rate band.[8] The presence of the intra–marginal interventions and the mean reverting tendency of the exchange rate suggest that a mean reverting policy rule would fit Swedish data better. Lindberg and Söderlind [1991] model the fundamentals with a regulated Ornstein–Uhlenbeck process and attempts to obtain estimates of the exchange rate function for Swedish data.

Second, according to Swedish data there is a positive correlation between the exchange rate and the interest rate differential. This clearly contradicts the theoretical prediction of a deterministic negative relation between the exchange rate and interest rate differential. It also rules out models of constant devaluation expectations. Diagram 5.2 shows the expected exchange rate after one year as deviation from central parity, calculated in accordance with Svensson [1991b]. The expected exchange rate has fluctuated heavily during the 1980's and the Swedish exchange rate band has frequently lacked credibility when the expected exchange rate is outside the exchange rate band). This suggests that a target zone model more suitable for the Swedish exchange rate band should include time varying devaluation expectations.[9] Bertola and Svensson [1990] develop a

[8]Data for this diagram cover only the periods 86:04:21 — 88:06:03 and 89:07:05 — 90:08:31.

[9]Betola and Caballero [1990] provides an alternative explanation of these two facts which seems

theoretical target zone model with stoachastic time varying devaluation expectations. On the basis of that extension, Rose and Svensson [1991] estimate time varying devaluation expectations for the French Franch/German Mark exchange rate and Lindberg,Svensson and Söderlind [1991] for the Swedish Krona.

interesting for some EMS currencies (particularly the French Franc and the Italian Lira), by assuming that there is a positive probability of a devaluation if the exchange rate hits the upper boundary. This tend to give a positive (deterministic) relation between the exchange rate and the interest rate differential, as well as an asymptotic exchange rate distribution with most of the probability mass in the middle. But, it can be argued that a this is not a very plausible process for devaluation expectations for the Swedish Krona.

Appendix 1. The Currency Basket Index

The Swedish currency basket index s, which has been in use since august 1977 is calculated according to

$$s_t = A_t \sum_i (w_t^i \epsilon_{base}^i / \epsilon_t^i)(\epsilon_t^{sek} / \epsilon_{base}^{sek}), \tag{A1.1}$$

where ϵ_t^i is the exchange rate, at time t, for currency i = {ats,bec,cad,cgf,dem,dkk,frf,gbp, itl,jpy,nlg,nok,usd,fim,esp} in US dollars. ϵ_{base}^i is the corresponding exchange rate in August 1977. The weights w_t^i and the adjustment factor A_t are found in table A1.1. The weights are based on five–year moving averages of shares in Swedish imports plus exports and are changed the 1st of April each year. The adjustment factor A_t is also changed at the 1st of April in order to keep the new index level at that date equal to the index level that would have prevailed if the old weights had still applied.

Table A1.1: Basket weights and adjustment factor

t	w^{ats}	w^{bec}	w^{cad}	w^{chf}	w^{dem}	w^{dkk}	w^{frf}	w^{gbp}
1977	1.9	3.9	1.2	2.6	16.7	9.5	5.3	13.9
1978	1.9	3.8	1.2	2.5	16.9	9.5	5.3	13.4
1979	1.9	3.7	1.2	2.5	17.0	9.5	5.4	13.1
1980	1.8	3.7	1.2	2.4	17.1	9.5	5.5	13.1
1981	1.8	3.7	1.2	2.4	17.1	9.3	5.6	13.1
1982	1.7	3.7	1.1	2.4	16.9	8.9	5.6	13.1
1983	1.6	3.7	1.1	2.3	16.6	8.5	5.6	13.0
1984	1.5	3.8	1.1	2.2	16.2	8.2	5.5	13.2
1985	1.4	3.7	1.0	2.1	15.9	8.0	5.4	12.9
1986	1.3	3.6	1.1	2.0	15.5	7.9	5.2	12.8
1987	1.3	3.6	1.1	2.0	15.6	7.8	5.2	12.2
1988	1.3	3.6	1.1	2.1	16.0	7.8	5.2	11.7
1989	1.3	3.7	1.2	2.1	16.4	7.6	5.2	11.1
1990	1.4	3.7	1.2	2.2	16.7	7.4	5.4	10.7

Table A1.1: Basket weights and adjustment factor (cont)

t	w^{itl}	w^{jpy}	w^{nlg}	w^{nok}	w^{usd}	w^{fim}	w^{esp}	A
1977	3.2	2.1	5.1	9.9	16.0	7.2	1.5	1.000000
1978	3.3	2.4	5.1	10.2	16.0	7.1	1.4	1.000000
1979	3.4	2.6	5.2	10.1	16.0	7.1	1.3	1.000000
1980	3.4	2.6	5.2	9.8	16.3	7.2	1.2	1.000000
1981	3.6	2.6	5.2	9.4	16.5	7.3	1.2	1.000000
1982	3.6	2.7	5.1	9.2	17.4	7.4	1.2	1.000000
1983	3.7	2.7	5.2	9.3	18.1	7.4	1.2	0.999318
1984	3.6	2.7	5.1	9.4	19.1	7.2	1.2	0.996692
1985	3.6	2.9	4.9	9.4	20.7	6.9	1.2	0.988950
1986	3.5	3.0	4.8	9.3	22.2	6.6	1.2	0.985859
1987	3.6	3.1	4.7	9.2	22.8	6.5	1.3	0.984710
1988	3.7	3.3	4.6	9.0	22.8	6.5	1.3	0.981203
1989	3.8	3.6	4.6	8.7	22.5	6.7	1.5	0.977405
1990	4.0	3.8	4.6	8.5	21.9	6.9	1.6	0.974516

Let s^i denote the Swedish exchange rate in terms of currency i. Then, the currency basket index can also be written as

(A1.2) $$s_t = A_t \sum_i w_t^i s_t^i / s_{base}^i.$$

Since $(s_t^i/s_{base}^i - 1)$ is the percentage change in the Swedish exchange rate in terms of currency i since August 1977, we note that the index s_t is a weighted average of percentage changes of the Swedish exchange rate in terms of the basket currencies.

Yet another way of looking at the definition is to regard $A_t w_t^i / s_{base}^i$ as a kind of weight. Then s_t is just an ordinary weighted average of the current Swedish exchange rates. Actually, this is the most useful interpretation. If an investor buys a portfolio consisting of the number $A_t w_t^i / s_{base}^i$ of currency i, for instance, 1*3.3/882.311 Italian Lire in 1978 where 882.311 was the SEK/ITL exchange rate in august 1977, then this portfolio will cost him exactly s_t SEK and at time $t+1$ is will be worth exactly s_{t+1} SEK. In terms of value shares of the portfolio, the value shares that achieves this are $w_t^i s_t^i / s_{base}^i / \sum_i w_t^i s_t^i / s_{base}^i$. Hence, the "effective" weights are functions of the current exchange rates. These two types of weights are compared in <u>diagram A1.1a–o</u>. For our purposes it is important to note that if the strong currencies (those whose value has increased more than the basket) have had lower interest rates during the historical period that we investigate, then using the basket weights will give an underestimated interest rate differential.

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Tables

Table 3.1: Exchange rate (percentage deviation from central parity)†

	820101–901115	820101–850626	850627–901115
Mean	–0.5332	–0.3902	–0.6266
Uncond std dev	0.6476	0.7811	0.5226
Cond std deviation[a]	0.1879	0.2186	0.1628
Min	–2.2422	–2.2422	–1.6055
Max	1.5174	1.5174	0.9178
No skewness[b]	0.2820**	–0.0859	0.4062**
No excess kurtosis[c]	–0.2107	–0.4859	–0.6697
Normality[d]	28.0505**	8.1234*	51.8757**
Homoskedasticity[e]	128.3294**	31.9650**	91.1643**
Unit root[f]	–4.5920*	–2.9536*	–3.6418*

†Rejection on the 5% significance level is denoted by *, while rejection on the 1% level is denoted by **.

[a]The conditional standard deviation is for one step–ahead forecasts error based on a fifth order AR.

[b]The asymptotic distribution for the skewness measure (a_3) is such that $T^{\frac{1}{2}} a_3 \sim N(0,6)$, where T is the number of observations.

[c]The asymptotic distribution for the excess kurtosis measure (a_4) is such that $T^{\frac{1}{2}} a_4 \sim N(0,24)$.

[d]Bera–Jarque's test for normality. The asymptotic distribution for the statistics is $\chi^2(2)$. See, for instance, Spanos [1986] for a description.

[e]White's test of conditional homoskedasticity. The test statistics is asymptotically distributed as $\chi^2(m)$, where m is the number of quadratic terms in the auxiliary regression (here 10). See, for instance, Spanos [1986] for a description. The variables used in the auxillary regression are 5 lags of the series studied.

[f]Augmented Dickey–Fuller test (using 5 lags) with intercept. The statistics should be lower than –2.87 in order to reject the hypothesis of unit root (non–stationarity) on the 5% significance level. See Fuller [1976].

Table 3.2: Interest rate differential (1 month)

	820101–901115	820101–850626	850627–901115
Mean	2.7448	2.3681	2.9928
Uncond std dev	1.8637	2.1848	1.5705
Cond std deviation	0.4531	0.6368	0.2722
Min	–6.2308	–6.2308	0.4845
Max	11.2797	11.2797	8.1046
No skewness	0.4377**	0.0562	1.5619**
No excess kurtosis	2.8554**	2.1548**	2.0791**
Normality	687.1651**	142.3834**	654.1701**
Homoskedasticity	473.1723**	230.3758**	21.5982
Unit root	–4.8793*	–3.2565*	–3.5419*
Corr(exchange rate)	0.0758	0.0453	0.1950

Table 3.3: Interest rate differential (3 months)

	820101–901115	820101–850626	850627–901115
Mean	2.6610	2.2829	2.9098
Uncond std dev	1.6031	1.8278	1.3816
Cond std deviation	0.2622	0.3377	0.1965
Min	–1.8079	–1.8079	0.6924
Max	8.3812	8.3812	8.1893
No skewness	0.8108**	0.5625**	1.6570**
No excess kurtosis	2.1383**	1.4082**	2.5928**
Normality	554.8763**	99.3536**	22.5693**
Homoskedasticity	450.5451**	305.3792**	19.0561
Unit root	–3.4158*	–1.5997	–3.5577*
Corr(exchange rate)	0.1002	0.0583	0.2454

Table 3.4: Interest rate differential (6 months)

	820101–901115	820101–850626	850627–901115
Mean	2.4027	1.8576	2.7615
Uncond std dev	1.4327	1.6153	1.1678
Cond std deviation	0.2140	0.2621	0.1737
Min	–1.8413	–1.8413	0.6274
Max	7.6965	7.3881	7.6965
No skewness	0.5811**	0.6821**	1.4714**
No excess kurtosis	1.8641**	1.6913**	2.1383**
Normality	371.7589**	144.3981**	614.7238**
Homoskedasticity	225.5582**	141.9872**	52.3603**
Unit root	–2.9597*	–1.0071	–3.3054*
Corr(exchange rate)	0.0951	0.0597	0.2987

Table 3.5: Interest rate differential (12 months)

	820101–901115	820101–850626	850627–901115
Mean	2.1018	1.3642	2.5875
Uncond std dev	1.2717	1.3210	0.9696
Cond std deviation	0.1956	0.2551	0.1439
Min	–1.6891	–1.6891	0.5123
Max	6.2526	6.2526	6.1107
No skewness	0.2044**	0.8505**	0.7992**
No excess kurtosis	0.6321**	1.9116**	0.3723**
Normality	43.6565**	200.2480**	125.1479**
Homoskedasticity	100.7944**	39.4225**	142.7088**
Unit root	–3.0553*	–1.6785	–2.4943
Corr(exchange rate)	0.0966	0.1041	0.3490

Table 3.6: Test of different unconditional variance against 1 month interest rate diff: Difference in standard deviation†

	820101–901115	820101–850626	850627–901115
Int diff (3 months)	–0.2606*	–0.3570	–0.1889
Int diff (6 months)	–0.4310**	–0.5695**	–0.4027**
Int diff (12 months)	–0.5920**	–0.8638**	–0.6009**

†The test is performed using the Newey—West [1987] covariance matrix, which takes into account serial correlation and heteroskedasticity.

Table 4.1: Comparison simulated and empirical exchange rate†

	Simulations	Empirical	Sim<Empirical
Mean	–0.0609	–0.6266	26.0000
	(0.6629)		
Uncond std dev	0.5200	0.5226	54.0000
	(0.1350)		
Cond std deviation	0.0488	0.1628	100.0000
	(0.0045)		
Min	–1.0531	–1.6055	0.0000
	(0.5055)		
Max	0.9704	0.9178	47.0000
	(0.4955)		
No skewness	0.0264	0.4062	78.0000
	(0.6807)		
No excess kurtosis	–0.4878	–0.6697	65.0000
	(1.3287)		
Normality	171.8963	51.8757	25.0000
	(411.3265)		
Homoskedasticity	57.9282	91.1643	81.0000
	(43.2094)		
Unit root	–1.7956	–3.6418	4.0000
	(0.8293)		

†Standard deviations within parenthesis. See Table 3.1 for further comments.

Table 5.1a: In–the–sample prediction errors: Standard deviation

	Entire sample
Lwr(5) ξ=0.30	0.0879
Lwr(5) ξ=0.50	0.1148
Lwr(5) ξ=0.90	0.1411
AR(1)	0.1662
AR(5)	0.1505

Table 5.1b: One–step–ahead out–of–sample predictions: standard deviation

	Last 100 obs	1989	Entire sample
Lwr(5) ξ=0.30	0.1473	0.1531	0.1785
Lwr(5) ξ=0.50	0.1418	0.1511	0.1659
Lwr(5) ξ=0.90	0.1407	0.1520	0.1618
AR(1)	0.1691	0.1644	0.1809
AR(5)	0.1409	0.1542	0.1621

Table 5.1c: 10–steps–ahead out–of–sample predictions: standard deviation

	Last 100 obs	1989	Entire sample
Lwr(5) ξ=0.30	0.2215	0.2973	0.3733
Lwr(5) ξ=0.50	0.2047	0.2895	0.3101
Lwr(5) ξ=0.90	0.1958	0.2891	0.2943
AR(1)	0.2078	0.2876	0.2980
AR(5)	0.1938	0.2881	0.2932

Table 5.1d: 30–steps–ahead out–of–sample predictions: standard deviation

	Last 100 obs	1989	Entire sample
Lwr(5) ξ=0.30	0.3608	0.4891	0.6569
Lwr(5) ξ=0.50	0.3131	0.4451	0.5677
Lwr(5) ξ=0.90	0.2710	0.4435	0.5067
AR(1)	0.2468	0.4387	0.4780
AR(5)	0.2571	0.4391	0.4866

Diagram 1.1

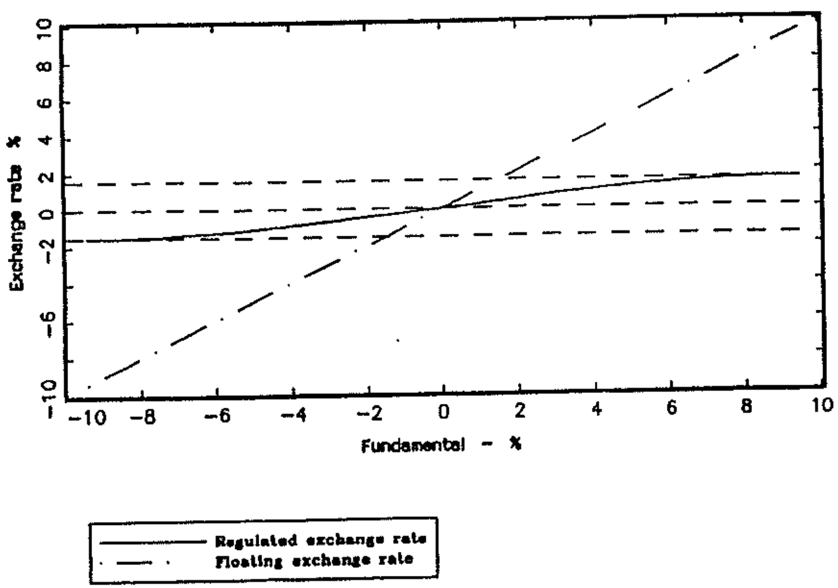


Diagram 1.2

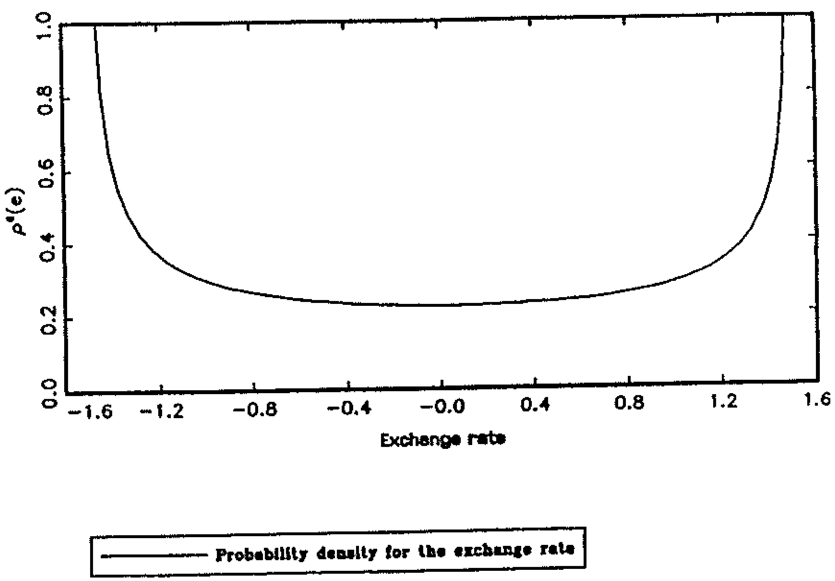


Diagram 1.3

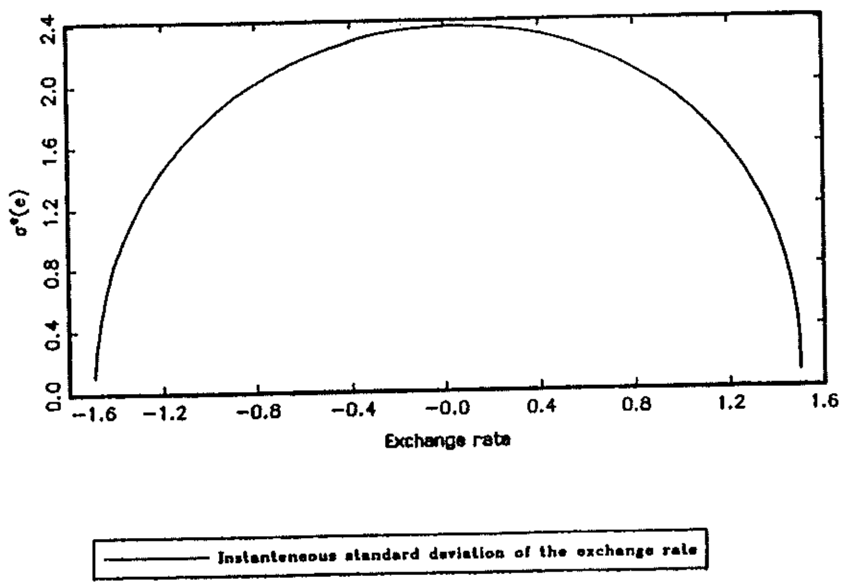
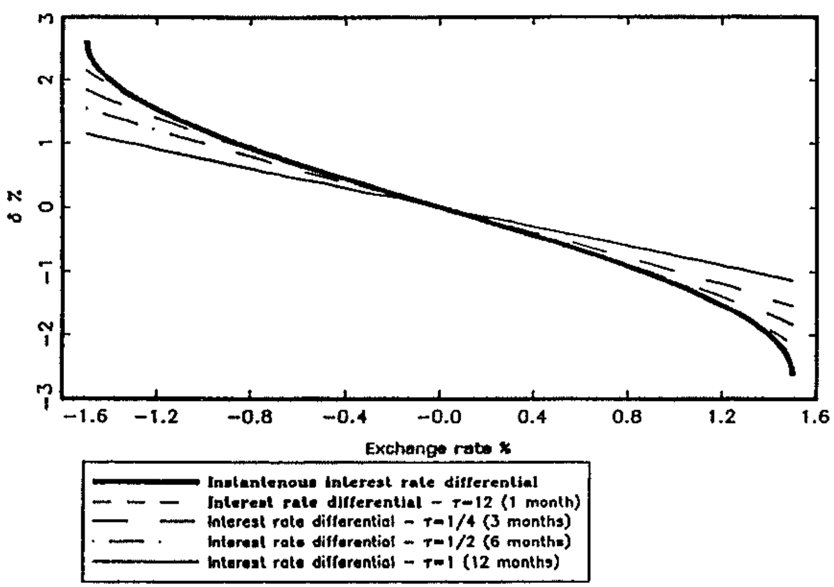


Diagram 1.4



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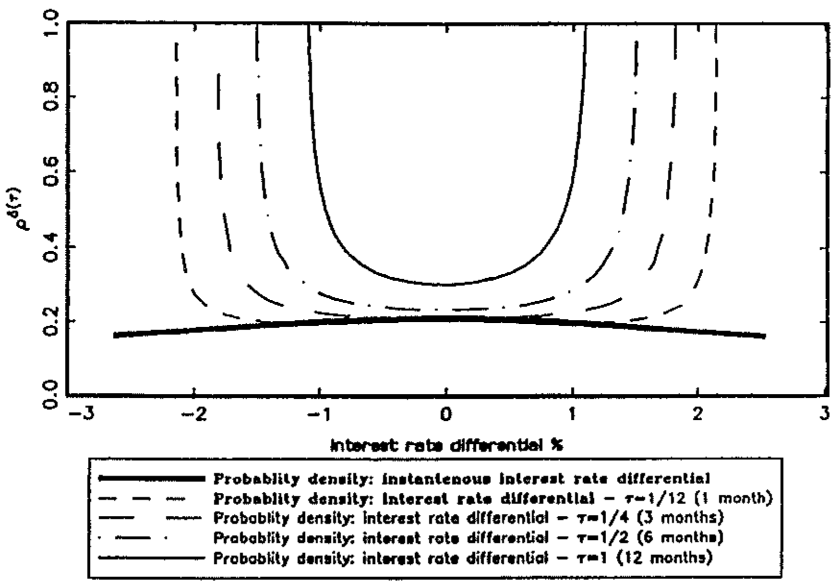


Diagram 1.6

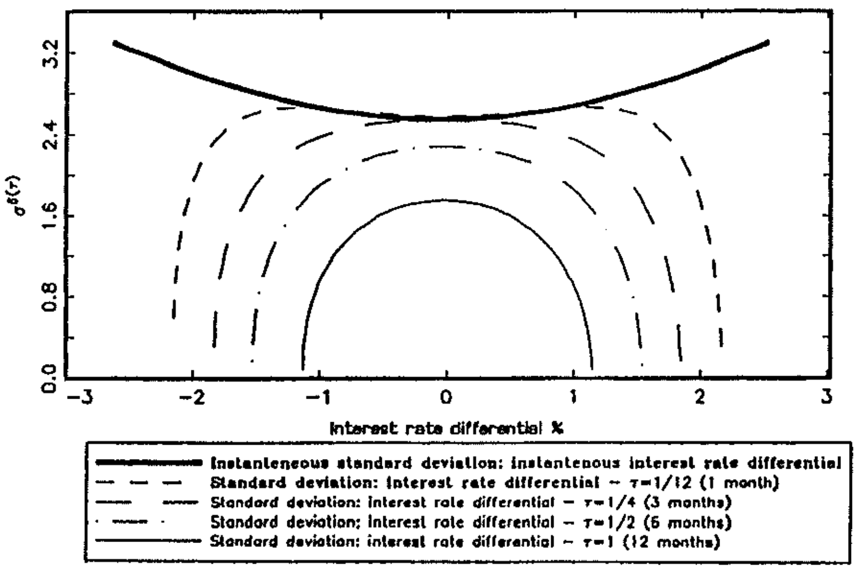


Diagram 3.1

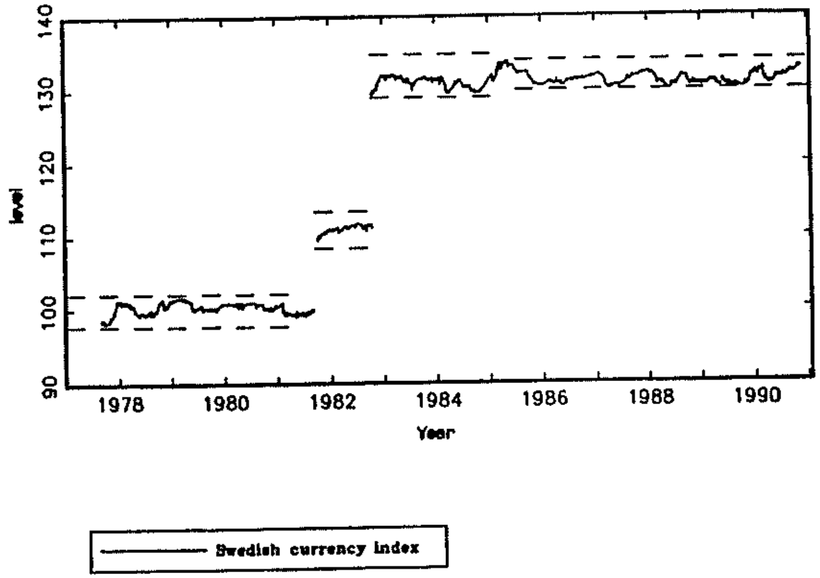


Diagram 3.2

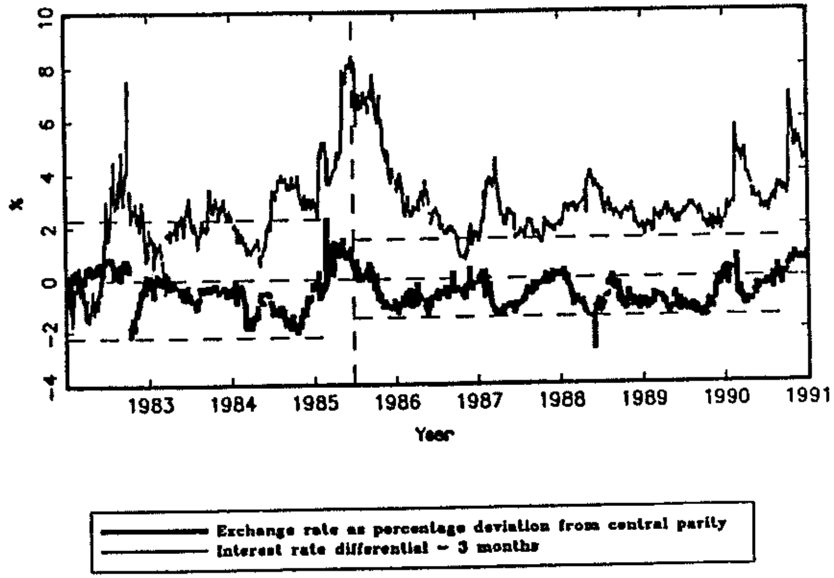


Diagram 3.3a

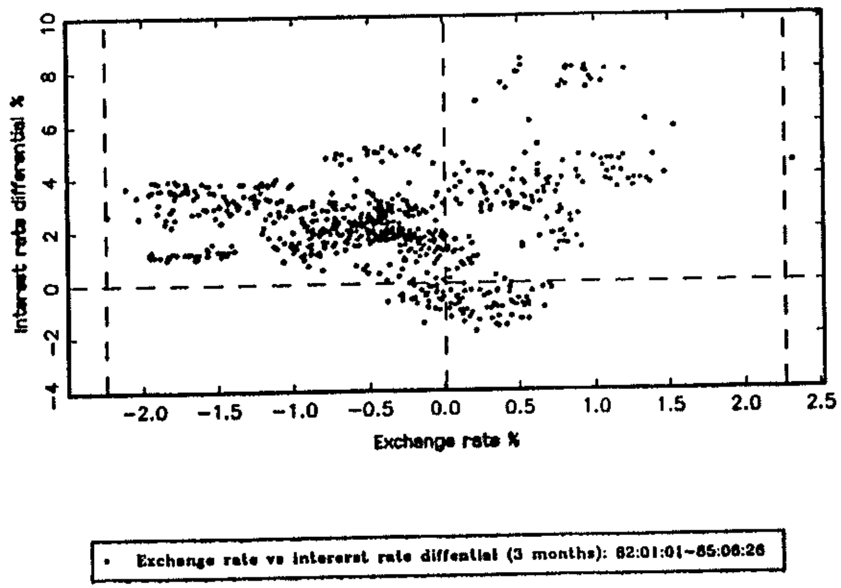


Diagram 3.3b

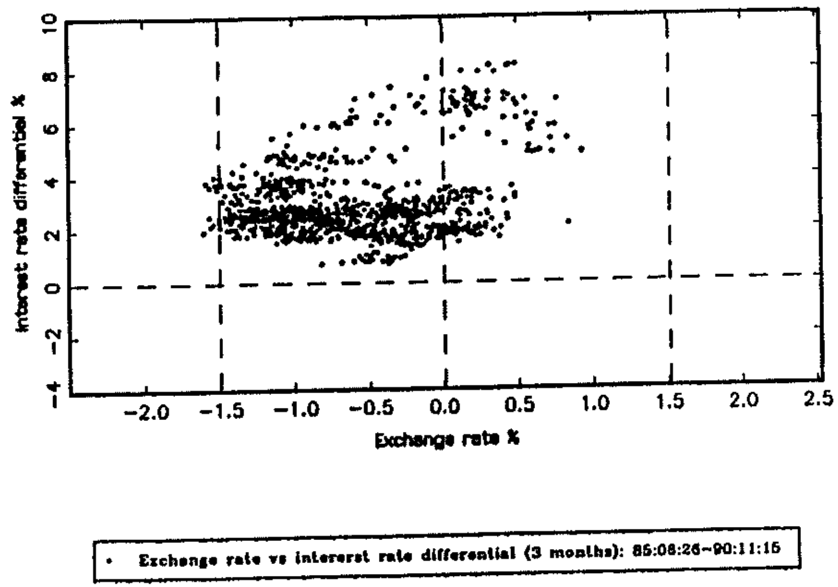


Diagram 3.4a

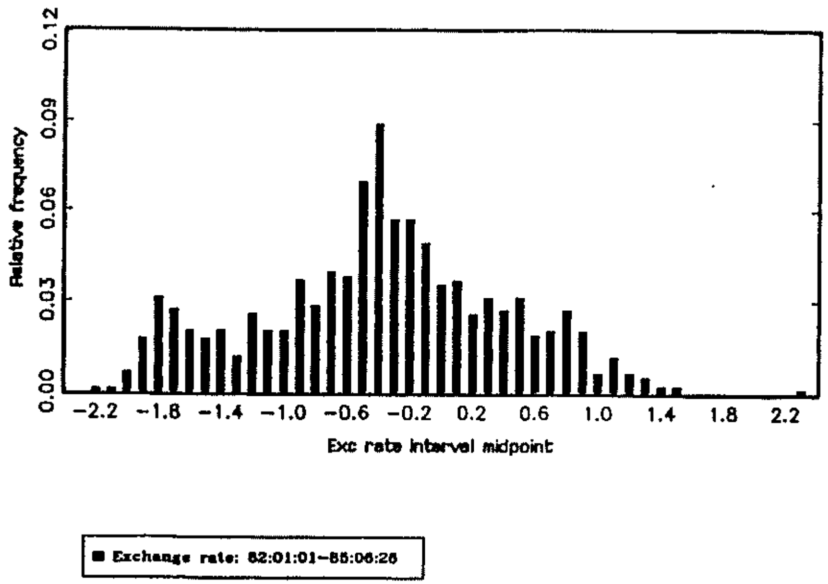


Diagram 3.4b

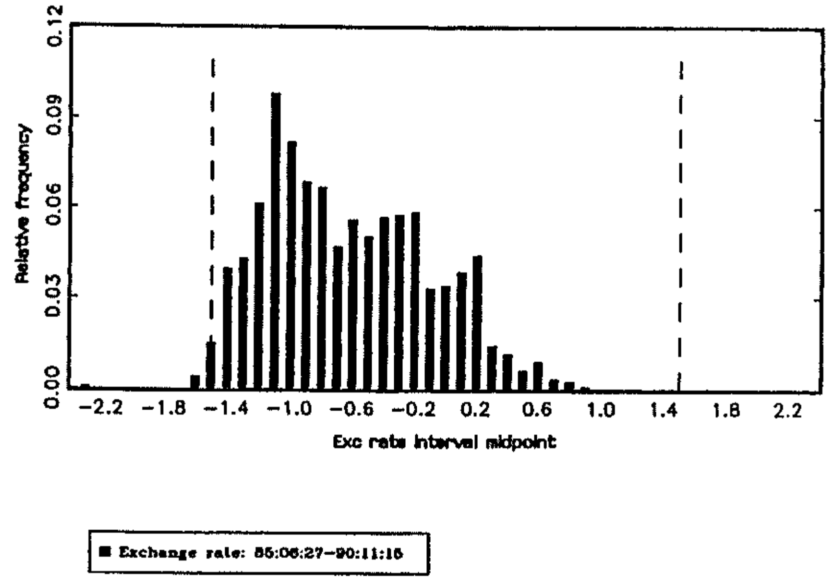


Diagram 3.4c

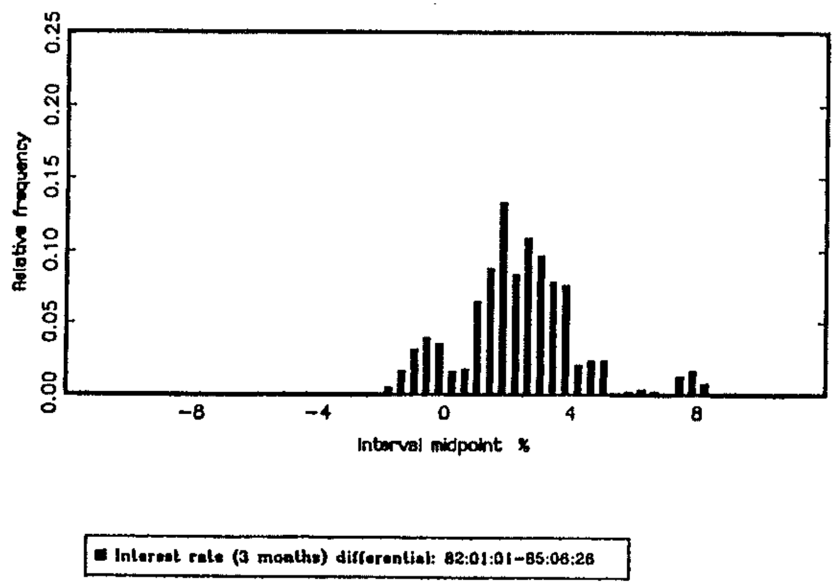


Diagram 3.4d

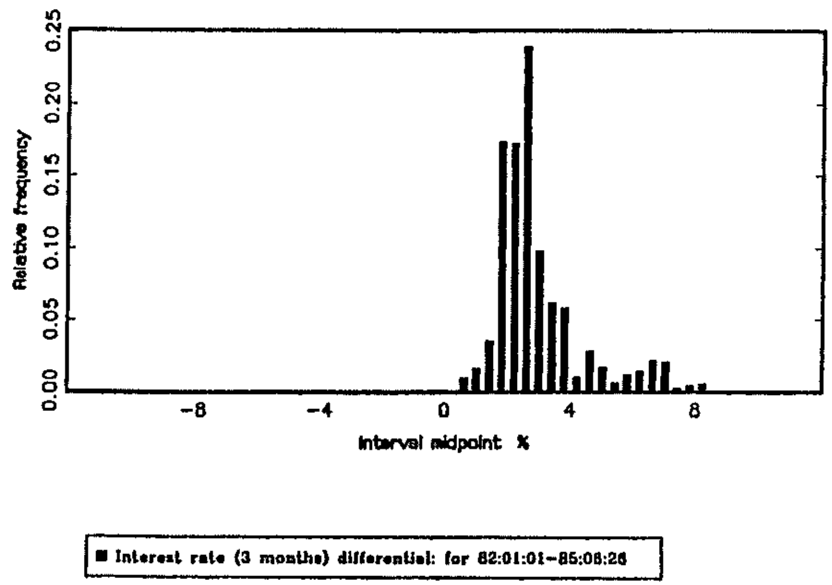


Diagram 3.5a

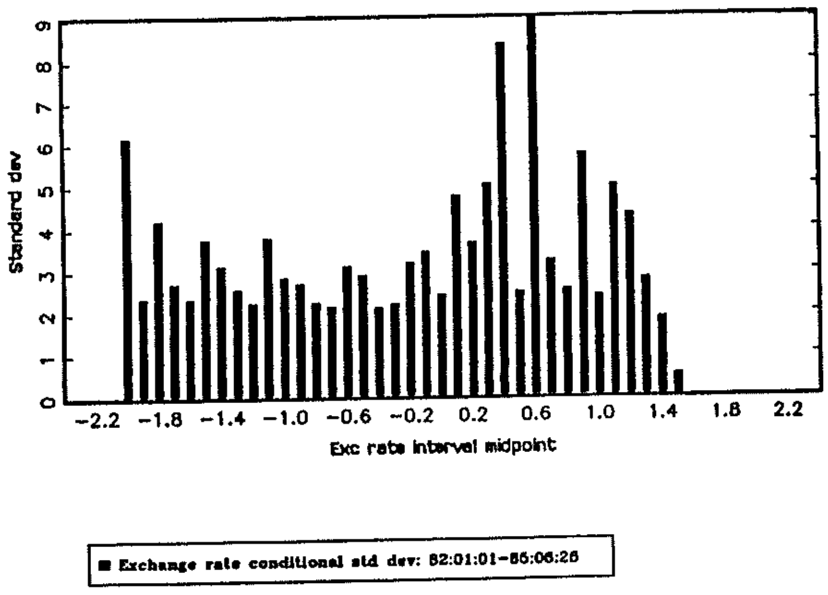


Diagram 3.5b

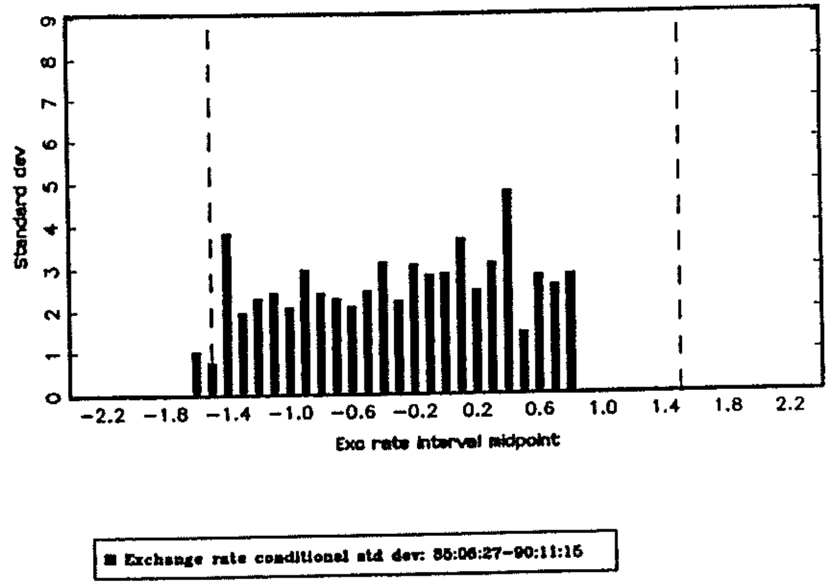


Diagram 3.5c

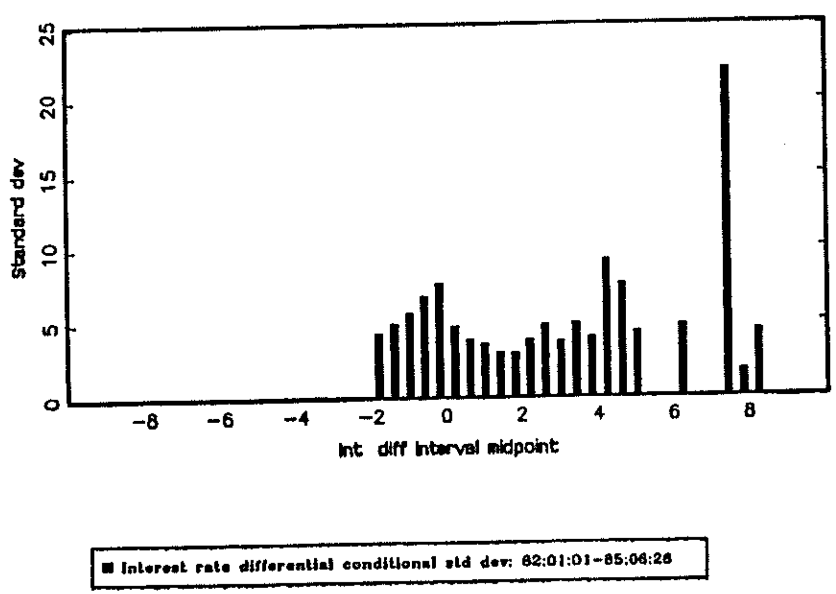


Diagram 3.5d

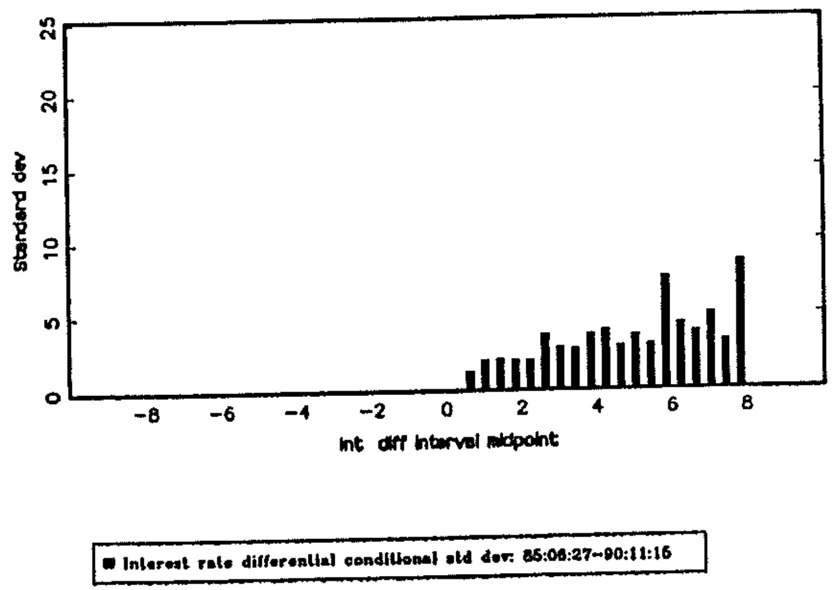


Diagram 5.1

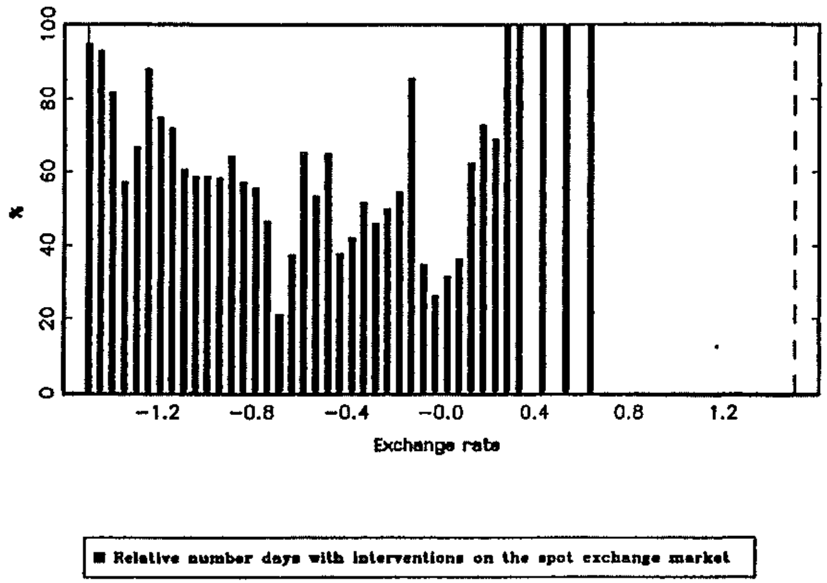


Diagram 5.2

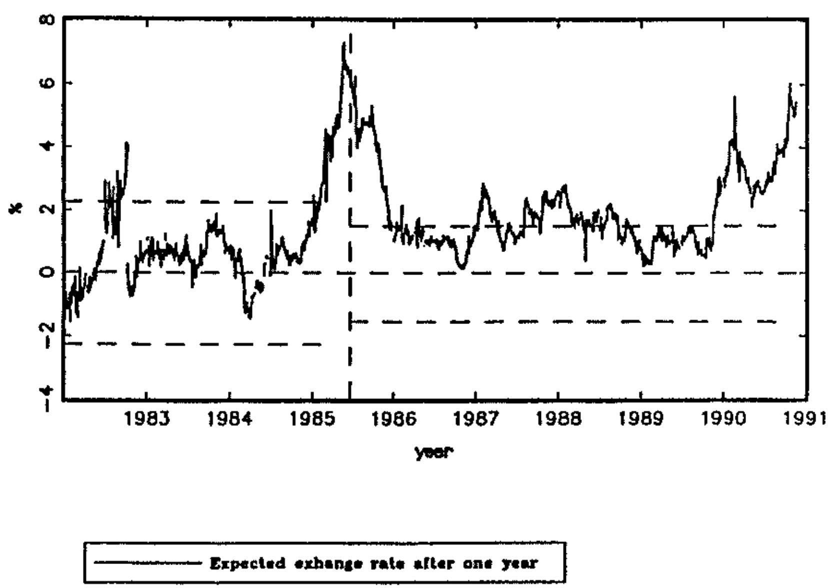


Diagram A1.1a

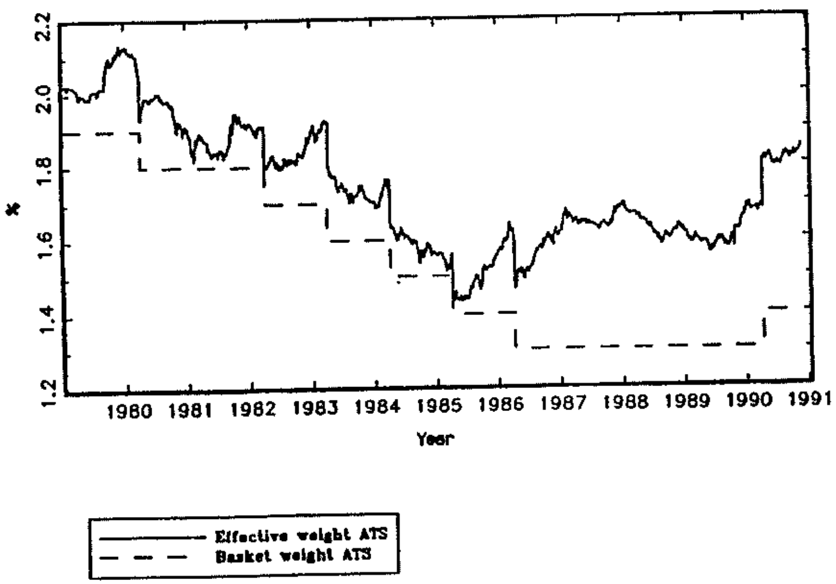


Diagram A1.1b

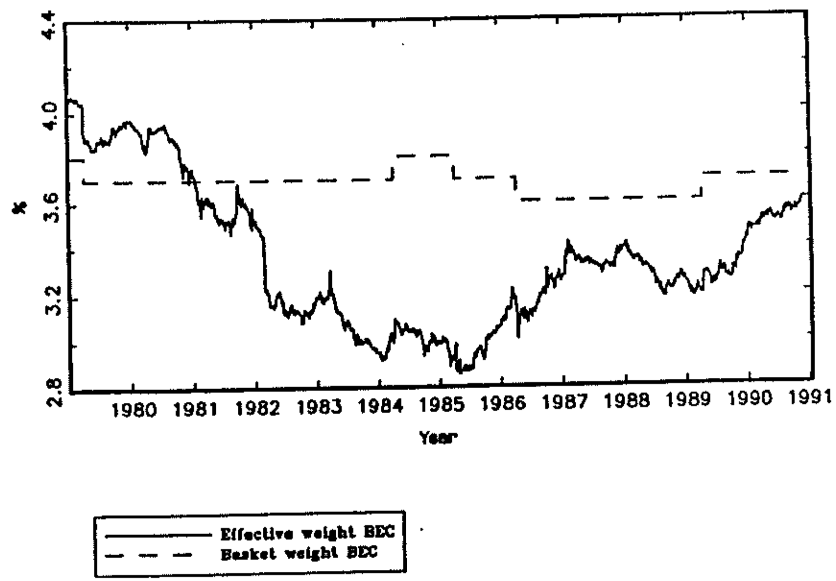


Diagram A1.1c

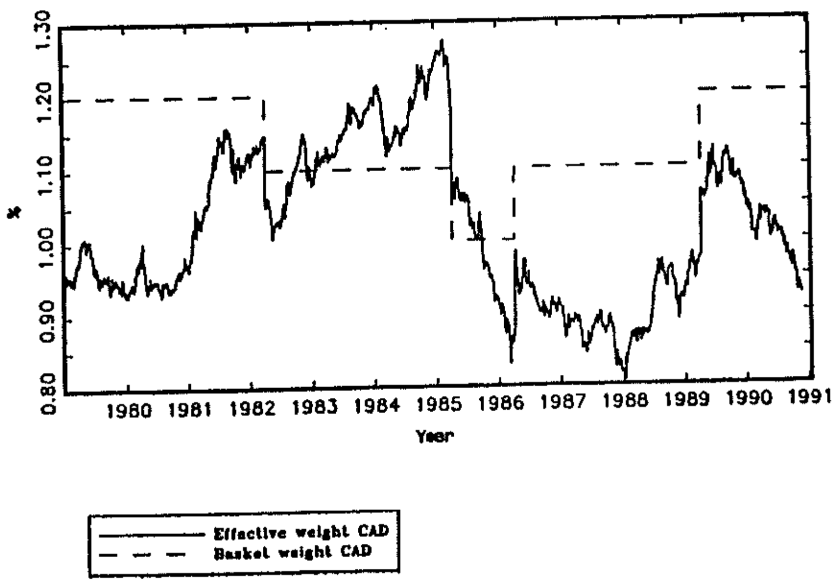


Diagram A1.1d

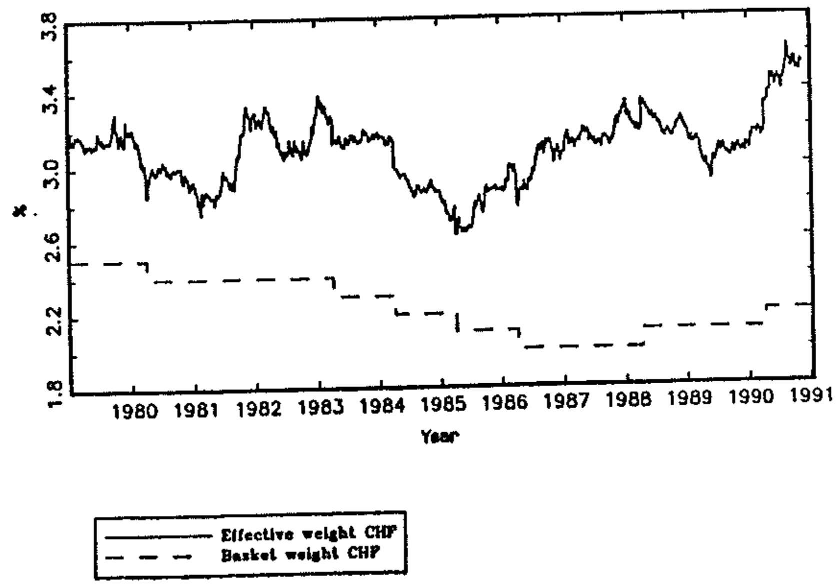


Diagram A1.1e

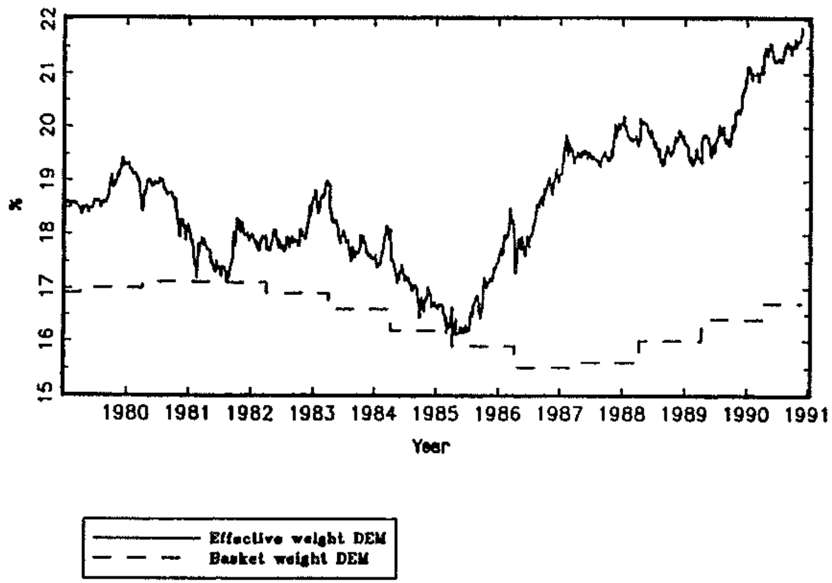


Diagram A1.1f

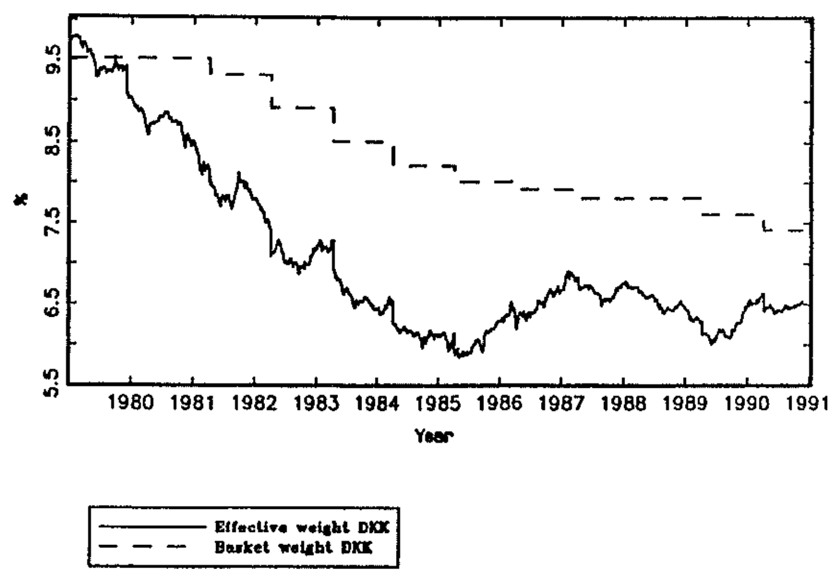


Diagram A1.1g

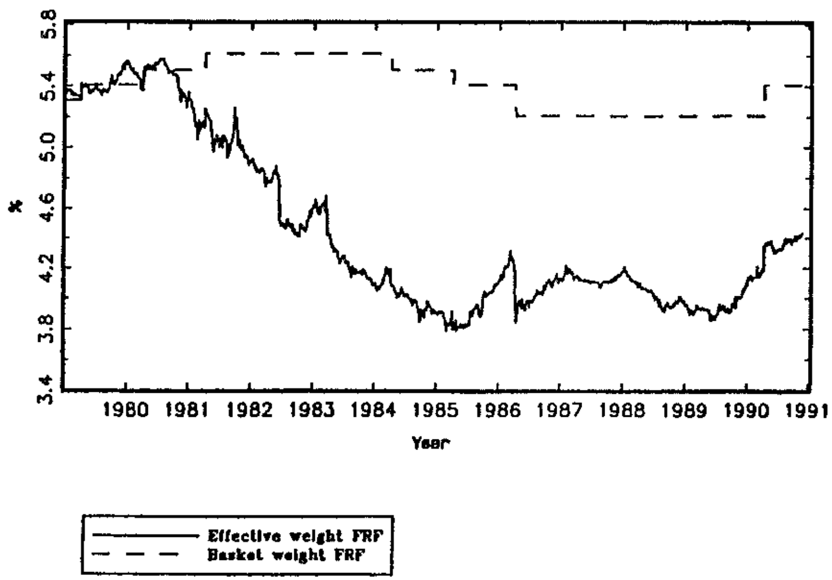


Diagram A1.1h

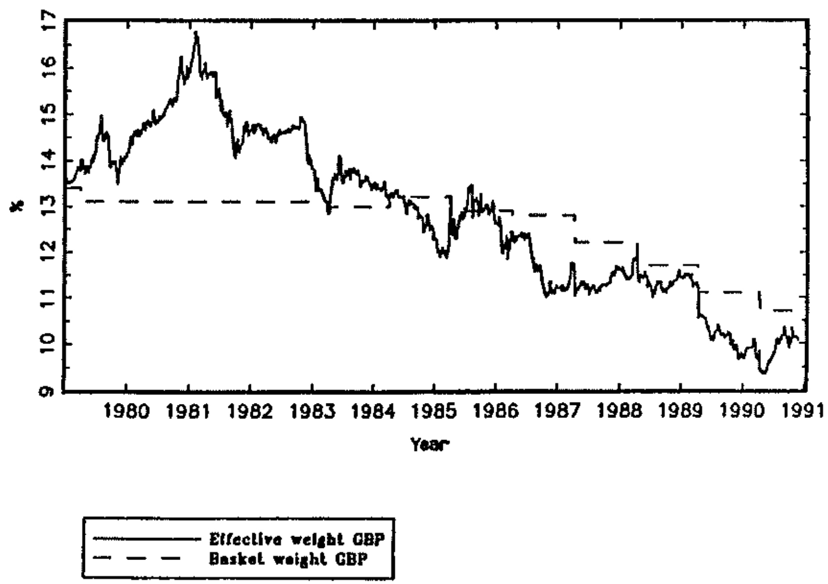


Diagram A1.1i

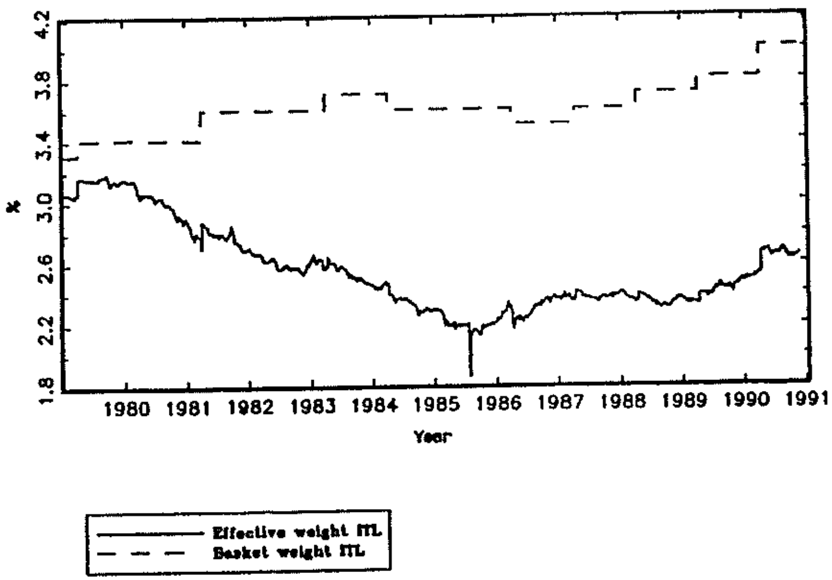


Diagram A1.1j

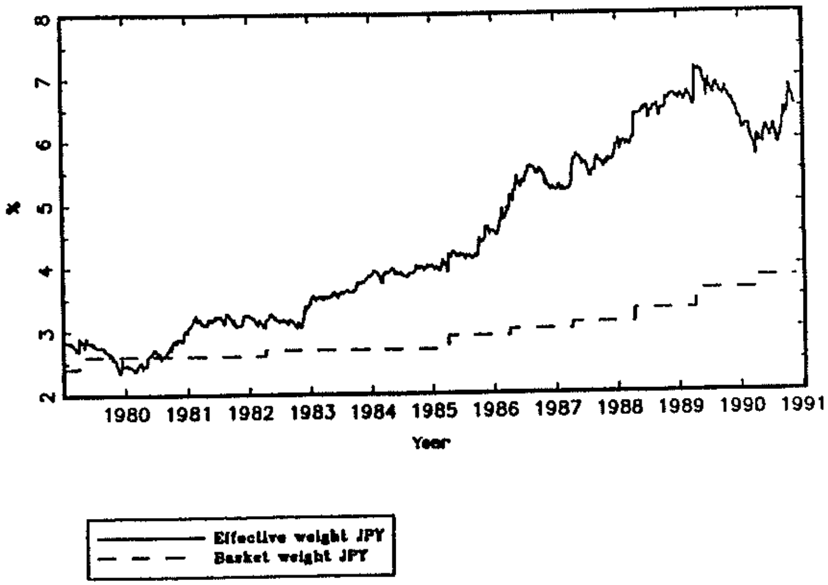


Diagram A1.1k

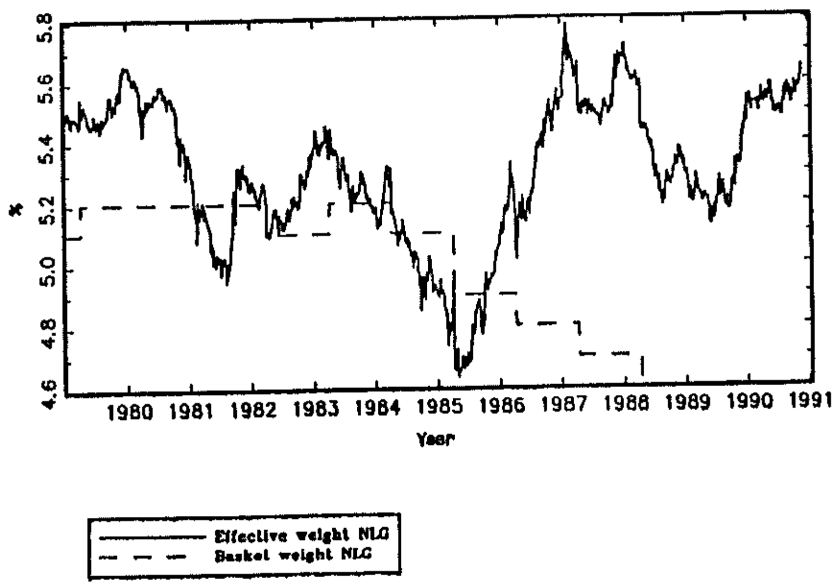


Diagram A1.1l

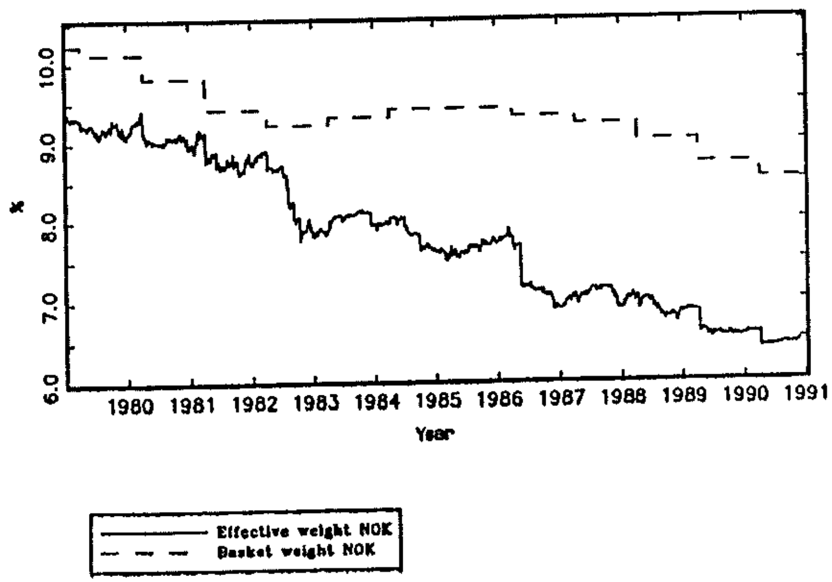
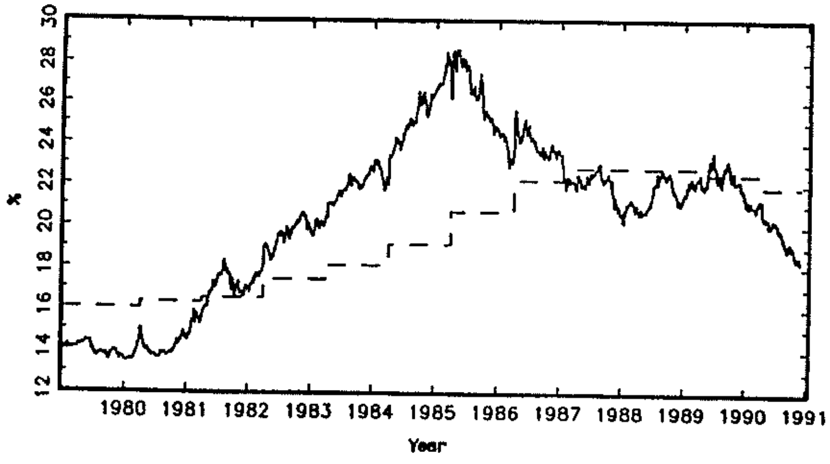
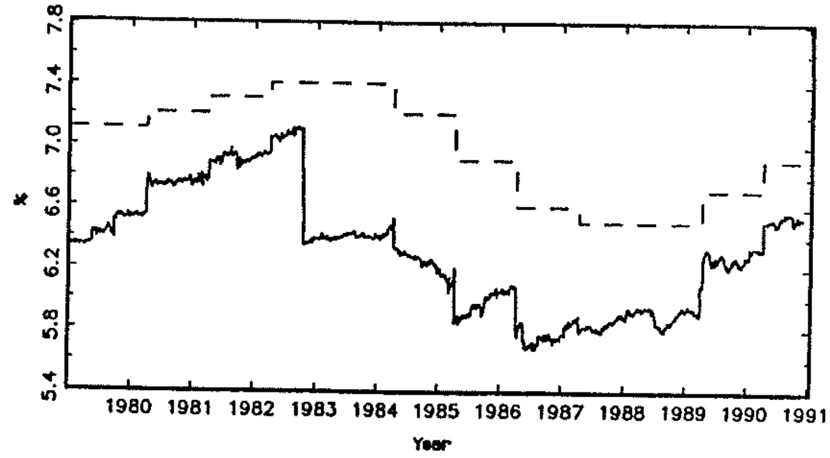


Diagram A1.1m



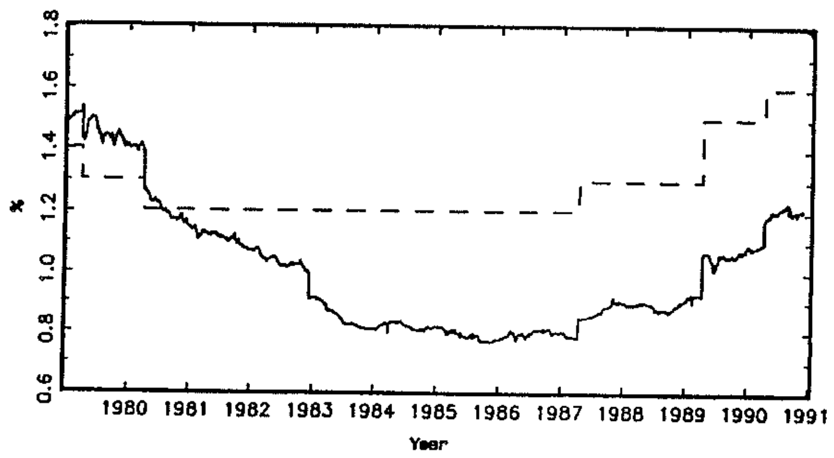
Effective weight USD
Basket weight USD

Diagram A1.1n



Effective weight FIM
Basket weight FIM

Diagram A1.1o



Effective weight ESP
Basket weight ESP