Olli-Pekka Lehmussaari* – Antti Suvanto* – Laura Vajanne**

Central Bank Policy Department
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The Currency Band and Credibility: the Finnish Experience

* Bank of Finland
** Union Bank of Finland

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ABSTRACT

This paper examines developments in the Finnish money and foreign exchange markets in the light of the recent literature on target-zones. The basket-pegging system, which was officially adopted in Finland in late 1977, provides a good opportunity to discuss some of the implications of the target-zone models. Analysis concentrates on the period after 1987 when the assumptions underlying the basic target-zone model can assumed to be fulfilled. Although empirical exchange rate distributions of the Finnish markka do not seem to resemble those predicted by the basic target-zone model, the findings of the paper support the view that for a given period Finnish data exhibit some of the implications of target-zone models. The results, however, indicate that causality runs from the interest rate differential to the exchange rate and not from the exchange rate to the interest rate differential as implied by the basic (credible) target-zone model. In addition, intervention practices carried out by the central bank appear to have played an important role in determining the expected future exchange rate within the currency band.

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1 INTRODUCTION

Finland was one of the first countries to peg its currency to a currency basket. After the collapse of the Bretton Woods system and the system of central rates, the basket-pegging system was adopted as a guideline for exchange rate policy in mid-1973. In November 1977, the basket-pegging system was formalized by an amendment to the Currency Act (Puro, 1978). At the same time the formal currency band was introduced. According to the Act, the external value of the markka was expressed in terms of a currency index number reflecting the exchange rates of the currencies most important for Finland's foreign trade.

Since 1977, the peg has been altered twice. In 1984, the Soviet rouble was removed from the currency index, and thereafter the calculation of the currency index was based on freely convertible currencies (Puro, 1984). In June 1991, the trade-weighted currency index was replaced by the peg to the Ecu.

The exchange rate arrangement adopted in Finland provides an opportunity to analyze developments in the money and foreign exchange markets in the light of the recent literature on target-zone models. In the analysis, we mainly concentrate on the period after 1987 when the assumptions underlying the basic target-zone model can assumed to be fulfilled in the Finnish money and foreign exchange markets.

Rather than trying to carry out a complete empirical assessment of the implications of the target-zone models with Finnish data, we apply descriptive analysis to recent episodes in the foreign exchange market in Finland and review the Finnish experience of maintaining the exchange rate within the band. We also use more formal methods in calculating the expected future exchange rate and the devaluation risk of the Finnish markka during the period when the markka was more or less constantly under severe pressure.

Although visual inspection of the data clearly reveals that many of the implications of the basic (credible) target-zone model are not consistent with the Finnish data, these inconsistances can to some extent be explained by the relatively large fluctuations in the devaluation risk.

In retrospect it is clear that the "fixed exchange rate test" which has been costly in many countries, proved to be extremely difficult in Finland. The Finnish experience shows, *inter alia*, that the difficulties of pursuing a structurally viable fiscal policy complicated the task of maintaining a stable exchange rate. In addition, the developments in the Finnish money and foreign exchange markets suggest that too much burden in the adjustment process was placed on monetary policy and too much was expected from labour market adjustment through wages.

The paper is organized as follows. *Section 2* describes the institutional characteristics of the foreign exchange rate system and reviews recent developments in the money and foreign exchange markets. The section also briefly discusses the operational mechanisms of monetary policy in Finland. In *Section 3*, the basic analytical framework is described and some of the weaknesses of the basic target-zone model are characterized. *Section 4* presents the empirical findings on the credibility of the Finnish currency band. In addition, the relationship between the interest rate differential and the position of the exchange rate inside the band is examined together with a brief discussion of the problem of the causality between the exchange rate and the interest rate differential. Also, various proxies for the expected future exchange rate within the band are introduced, which are then used empirically. At the end of the section estimation results of the time-varying devaluation risk are presented. *Section 5* rounds up the discussion with concluding remarks.

2 DESCRIPTIVE ANALYSIS

2.1 Institutional Framework

Since March 1962, the decision making procedure regarding the external value of markka has been defined in the Currency Act. The Bank of Finland is responsible for maintaining the exchange rate (index) within the band, but the Government is the ultimate decision maker as regards any realignment of the band, including changes in the width of the band. The proposal for a realignment must come from the Board of Management of the Bank and it must be accepted by the Parliamentary Bank Supervisory Board. The Government can either accept the proposal as it stands or reject it.

This decision making procedure was already applicable in the Bretton Woods era, although the central gold parity and the width of the band *vis-à-vis* the US dollar was set by the agreement with the IMF. Formally, the currency band was introduced by the amendment of the Currency Act in November 1977. Since then, the width of the band has been changed a few times, alternating between ±2¼ and ±3 per cent. Since November 1988, the width of the band has been ±3 per cent. According to the current interpretation of the law, any larger changes in the width of the band, as well as revisions to the composition of the basket, require amendments to the Currency Act (Lehmussaari, 1991, and Åkerholm, 1992).

2.2 *Deregulation and Capital Movements*

Despite changes in the peg and in the width of the band, the exchange rate regime has remained formally unchanged for most of the postwar period. The role of the exchange rate and exchange rate policy have, however, undergone considerable changes.

Figure 2.1 portrays the history of the exchange rate during the period when the formal basket peg has been in use. It reveals, *inter alia*, that large jumps in the exchange rate dominate the picture and that the upward jumps (devaluations) dominate the downward adjustments (revaluations). Some of the discrete adjustments have taken place within the band, although in the majority of cases the entire band has been adjusted. In the period up to 1985, the index was not allowed to move within the band to any significant extent, except on a few occasions when it was discretely adjusted.

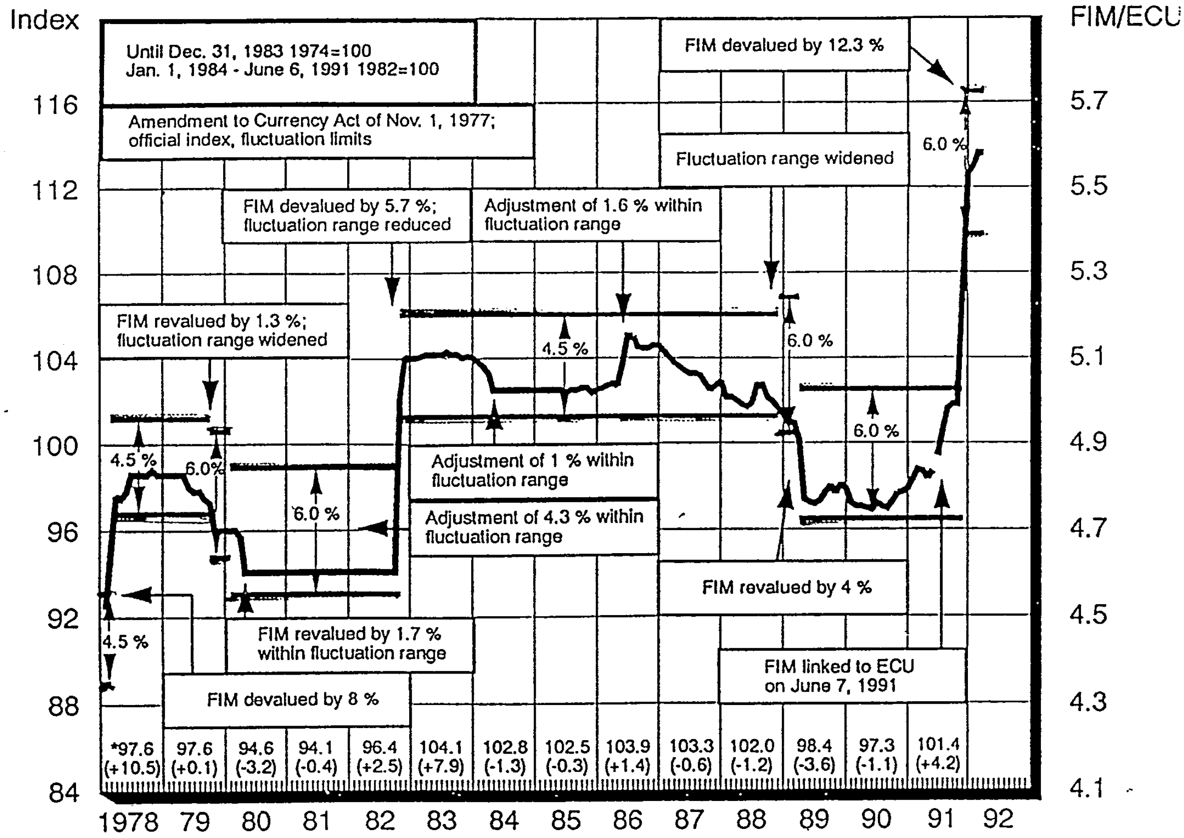
As long as capital movements and domestic financial markets were tightly regulated, capital movements were slow to react to changes in monetary tightness at home relative to that abroad. As a result, monetary policy had a considerable degree of autonomy and, in addition, the exchange rate could be used as an independent instrument of economic policy. During the period of strict regulation, which in Finland lasted longer than in most OECD countries, interest rate policy was geared mainly toward demand management and structural objectives, whereas decisions on exchange rate policy were based mainly on maintenance of the competitiveness of the export sector (Swoboda, 1986, and Åkerholm, 1987).

Although interest rate regulation and exchange controls were continued until the mid-1980s, their efficiency already had started to diminish in the latter half of the 1970s. The early 1980s witnessed widespread circumvention of interest rate regulations and exchange controls by operators, mainly domestic firms and banks, in the forward exchange market as well as in the rapidly growing unregulated money market.

The currency was subjected to a strong speculative attack in autumn 1982, to which the authorities responded by a discrete devaluation within the band. Not surprisingly, this move did not alleviate the pressure, and a few days later the markka was devalued for the second time by an upward adjustment of the band as a reaction to a large surprise devaluation of the Swedish krona.

Speculative capital outflows reappeared one year later, in autumn 1983. This time the Bank of Finland reacted by promptly raising the call money interest rate, which, in turn, pushed up both forward exchange rates and interest rates in the unregulated money market. This episode provided a foretaste of the interplay between capital flows, interest rates and exchange rates, as well as of their interrelationship with economic policy in general.

Figure 2.1 *Bank of Finland Currency Index*



* Annual average of index. Change (%) from previous year in brackets. Old index for 1991.

Some important changes regarding attitudes to exchange rate policy had already taken place before autumn 1983. Two discrete revaluations in 1979 and 1980, although small, marked the first serious attempt to depart from the ten-year devaluation cycle (*cf.* Korkman, 1978, Halttunen and Korkman, 1984). A shift from 'competitiveness oriented exchange rate policy' to a strategy emphasizing exchange rate stability was proclaimed for the first time in the programme of the new Government which took office in spring 1983. The same strategy has since been proclaimed in each subsequent Government programme (in 1987 and 1991), despite changes in the political composition of the Government.

The tide suddenly turned in early 1984, after which stability became threatened by heavy capital inflows. Captive financial institutions invented new channels to circumvent existing regulations, and foreign investors entered the markka market for the first time in the postwar period.

In 1986, stagnation of growth, a sharp fall in oil prices and consequent decline in Finland's exports to the USSR, together with a discrete devaluation in Norway, triggered repeated attacks against the markka. In May, the exchange rate was adjusted by a small discrete devaluation within the band. This move appears to have poured fuelled speculation even more and within a short period the Bank of Finland lost almost all its reserves. The attack was repelled by a sharp increase in the call money interest rate (to 40 per cent) in early August, but the crisis did not recede until the end of the year, when it had already become obvious that, rather than being in the midst of a recession, the economy had already embarked on a strong cyclical upswing.

The 1986 experience speeded up the formal deregulation process. Bank lending rate controls were dismantled entirely in 1986. Deposit rates nevertheless remained administratively rigid because of the continuation of the tax exemption of interest income on bank deposits and because of the rigidity of the Bank of Finland's base rate, to which most deposit and lending rates were linked.[1] Controls on capital imports were lifted step by step during the subsequent years. The process was, however, asymmetric. While capital imports were liberalized at a rapid pace, capital exports remained more or less regulated until 1990.

The turnaround in the international business cycle in 1987, together with the domestic credit boom and bullish income expectations, led to a rapidly deteriorating external balance and to a sharp increase in asset prices in 1988 and 1989. Finland's terms of trade improved each year from 1986 to 1989, by a total of around 20 per cent, which boosted domestic demand still further. Although central government finances exhibited growing surpluses, automatic stabilizers and attempted discretionary measures were unable to choke off excess demand.

As further monetary tightening through open market operations, which by then had become the conventional practice of monetary management, became impossible as early as in mid-1988 as the exchange rate index hit the strong edge of the currency band. In early 1989 the authorities took recourse to two unconventional measures. From the beginning of March, the Bank of Finland reguired the banks to make supplementary cash reserve deposits from banks, the size of which depended on the rate of credit expansion of each bank or banking group.[2] A few weeks later, the Bank of Finland and the Government decided to revalue the markka by around 4 per cent. Neither of these measures had a major immediate impact. The interest rate differential between domestic and foreign interest rates widened temporarily as a result of the surprise revaluation, but the rate of credit expansion by banks proved slow to diminish, despite pecuniary costs to banks

[1] The Bank of Finland's base rate may be somewhat misleading as a term, because the ultimate decision on is made by the Bank's Parliamentary Supervisory Board. This explains its upward rigidity, which may not have been a problem in times of stright regulation and credit rationing. The asymmetry in deregulation and the political ridgidity of the base rate probably sowed the seeds of future imbalances in the banking sector, as bank deposit rates did not rise in line with market rates and banks funded their new lending increasingly in the wholesale market (incl. the forward exchange market). The interest margin was further reduced later as the cost of funding had increased while but the rates on outstanding loans tied to the base rate remained at a low level.

[2] Supplementary cash reserve requirements were intended to penalize aggressive lenders and to raise bank lending rates in order to reduce credit demand. The system was in force from March 1989 to the end of that year.

brought about by the supplementary cash reserve deposits which were collected until the end of the year.

Market sentiment changed abruptly in autumn 1989, by which time it had become obvious that the economy was on an unsustainable path. Foreign investors, in particular, who over the years had become increasingly interested in the high-yielding Finnish markka, reduced their positions as a reaction to a sequence of negative news concerning the current account and inflation developments. It appears that foreigners were better able than the Finns to distinguish 'the wood from the trees' in reading Finnish macroeconomic and political data.

The period from autumn 1989 up to the present time has been characterized by successive episodes of currency unrest and periods of relative calm, each of which would merit an in-depth 'clinical study'. The spring and summer of 1990 represent a period relative calm, but this ended suddenly as uncertainty surrounding the following year's budget and the forthcoming wage negotiations began to grow.

The uncertainty concerning the outcome of the general election in March 1991 prompted a new wave of speculation, which was resumed in late May after the decision by Sweden to switch the peg from a trade-weighted basket to the Ecu. A similar move by the Finnish Parliament in early June calmed the situation for some months, but the autumn brought with it two waves of massive speculation, the latter culminating in a discrete devaluation of the markka by 12.3 per cent on 15 November 1991.

2.3 Operational Mechanims of Monetary Policy[3]

As is apparent from the discussion above, the deregulation of financial markets and the dismantling of exchange controls have resulted in a major change in the role of the exchange rate. At the same time it has changed the operational mechanisms of monetary policy. Free capital movements and free interest rate formation have broken down the traditional distinction between monetary policy and foreign exchange policy. Changes in the interest rate differential *vis-à-vis* foreign rates have an immediate impact on either the exchange rate or foreign exchange reserves. Changes in foreign exchange reserves affect the monetary base (amount of liquidity in the banking system) and interest rates. A change in liquidity and interest rates is quickly offset by capital movements.

Using the popular terminology, the *ultimate* target of monetary policy is price stability (low inflation). This objective has been stated in each Government programme since 1983. The exchange rate is the *intermediate* target. If the exchange rate (currency index) is to remain within its prescribed limits, the rate

3 For a detailed description, see Suvanto (1990).

of inflation in Finland cannot for long differ from the average inflation rate for the countries whose currencies are included in the index to which the markka is pegged.

The exchange rate (within the band), the interest rate and the exchange reserves (or alternatively bank liquidity) consitute the three *proximate* targets of monetary policy. In the short term, the central bank can exert some influence on all of these through market operations, but it is not free to choose every one of them independently. For instance, an open market purchase that increases bank liquidity and thereby lowers the short-term interest rate, leads, *ceteris paribus*, to currency depreciation (restricted by the band) or to a decline in reserves (restricted by adequacy considerations).

This characterization was not illustrative of the operational environment in which monetary policy in Finland was conducted in the 1970s or the first half of the 1980s. Open market operations in the domestic money market could not exist before 1987, because there was no properly functioning domestic money market.[4]

Since 1987, open market operations have been the principal instrument for implementing the Bank of Finland's monetary policy (Aurikko, 1989). Initially, the Bank of Finland relied exclusively on outright open market operations. The operations affect banks' liquidity on the spot date (two days following the trade date).[5] Since early 1991, repo or reverse repo tenders have played an increasingly important role in day-to-day liquidity management. These are arranged at frequent, though irregular, intervals in order to smooth large changes in liquidity, arising, *e.g.*, from government loan transactions or from the expiration of earlier central bank transactions.

As the liquidity control function has been implemented through open market operations, the need for intervening spot in the foreign exchange markets has diminished. Both interest rates and the exchange rate have been allowed to react to a greater extent to pressures stemming from capital movements. Interventions in the spot market are, as a rule, unsterilized or only partially sterilized. From time to time, the Bank of Finland has resorted to swap operations in the forward exchange market. The experience of later years shows that the possibility of raising domestic interest rates by sterilizing the liquidity effects of capital imports has been reduced by the deregulation of capital movements. Forward exchange

[4] Since 1980, the forward exchange market had functioned as a substitute for the otherwise nonexistent domestic money market and as a new channel for short-term capital movements, which made it possible for the Bank of Finland to utilize forward exchange market intervention as a means of controlling liquidity. Forward exhange operations were used extensively in 1983 and 1984 in order to sterilize the liquidity impact of capital inflows (*cf.* Lindroos, 1989).

[5] In exceptional cases, the Bank of Finland has carried out money market operations in the deposit market in overnight, one-week and two-week maturities. These contracts differ from other operations in that their value date coincides with the trade date.

sales by the central bank during periods of currency turmoil have been relatively small in comparison to the amount of intervention in the spot market.

The significance of the call money (discount) window as a source of banks' central bank financing has diminished substantially since open market operations became available as a means of controlling liquidity.[6] Previously the call money credit facility was the banks' only source of central bank financing. At the beginning of 1986 the interest rate on call money credit was differentiated from the rate on call money deposits in an attempt to induce banks to smooth out the differences in their liquidity needs in the interbank market for overnight funds. Every bank that had access to central bank finance could obtain call money credit up to a specified quota. The administratively set rate of interest charged within the quota (call money credit rate) was 13 per cent; a rate of 19 per cent was applied to borrowing in excess of the quota. Interest was paid at the rate of 7.5 per cent on call money deposits.

In June 1989, bank-specific quotas were abolished as part of a revision of the facility. In order to induce banks to resort to the call money window only for temporary purposes and to hold their free reserves in the form of call money deposits at the Bank of Finland, the banks were oblied to maintain a positive 5-day moving average for their daily positions at the Bank. The call money credit rate was raised from 13 to 15 per cent and the call money deposit rate lowered from 7.5 to 4 per cent. In November 1989, a monetary penalty was laid down for failure to observe the five-day rule. Whenever the five-day moving average of a bank's daily position was negative, the bank had to pay twice the normal rate for call money credit (30 per cent).

Under this arrangement, a bank's temporarily greater-than-normal level of call money credit had to be offset by making call money deposits at the Bank of Finland in excess of the normal level within the following five days. This increased the banks' marginal cost of call money credit, which was actually one of the main purposes of the revision. By granting small amounts of temporary call money credit at reasonable rates but making repetitive or excessive use of the facility costly, it was hoped that the banks would be induced to improve their liquidity forecasts and that fluctuations in banking system liquidity would be immediately and totally reflected in short-term interest rates.

Subsequent to the revision of the call money facility, banks have no longer used this facility for borrowing from the central bank, except momentarily in individual cases. In the cace of unrest in the currency markets the use of the facility has automatically led to a sharp rise in short-term interest rates as liquidity has been tightly squeezed. On the other hand, fluctuations in bank reserves, and

[6] For a thorough analysis of the call money window, see Pulli (1992).

their asymmetric distribution across banks, have from time to time contributed to excessive volatility of short-term rates.

In July 1992, the existing call money facility was replaced by a new system for regulating the supply of bank liquidity. The new system differs from the previous one in that the deposit and borrowing rates are closer to market rates of interest and move in line with changes in market rates. At the same time, the new facility is expected to reduce excessive interest rate volatility at the short end of the yield curve. The rates are tied to the current tender rate (the rate obtained in the latest tender arranged by the Bank of Finland for one-month funds). The excess reserves, which appear as positive overnight balances on banks' reserve accounts with the Bank of Finland attract interest which is 1 percentage boint below the tender rate. The borrowings through the facility, so-called liquidity credit, may have a maturity from 1 to 28 days and the rate of interest is 1 percentage point above the tender rate. The term of the liquidity credit is currently 7 days.

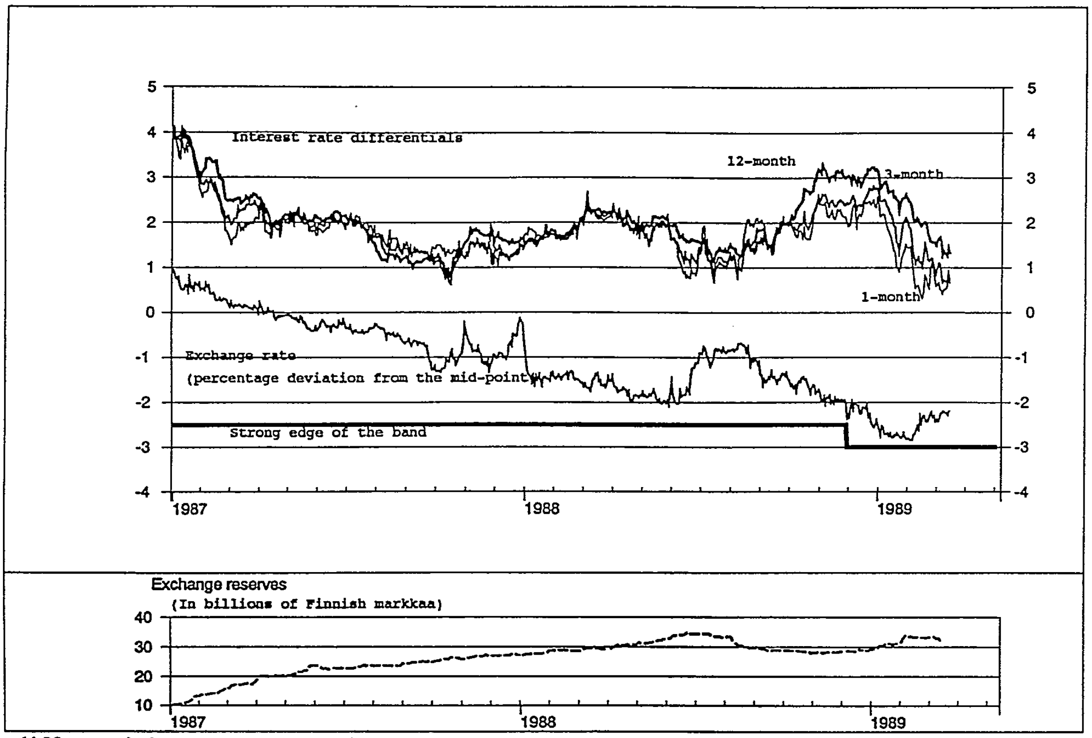
One further consequence of the possibility of undertaking open market operations is that the significance of cash reserve deposits in the control of liquidity has diminished. Desired changes in liquidity can be achieved at any time by operating in the money market, whereas the cash reserve deposit requirement can be adjusted once a month at best and even then by very limited amounts. The cash reserve deposits depend with a lag on the deposit base of the bank and are frozen for one month at a time. They allow no flexibility and therefore cannot be regarded as a part of the central bank's liquidity systems. They are based on an agreement between the Bank of Finland and the banks, and their main role is to collect seignorage tax from banks and to act as a collateral against banks' borrowings from the central bank (including intraday borrowings).

2.4 Exchange Rate, Interest Rate Differentials and Foreign Exchange Reserves

Figures 2.2 and *2.3* show movements in the above-mentioned proximate targets of monetary policy since the beginning of 1987. *Figure 2.2* covers the period from the beginning of January 1987 up to the revaluation on 17 March 1989. *Figure 2.3* covers the post-revaluation period up to 14 November 1991, the eve of the devaluation. The division into two periods was made because there are good reasons to believe that data-generating processes differ between the two periods in a number of important respects.

The upper panel portrays the interest rate differential for the 1, 3 and 12-month terms, as well as the exchange rate (external value of markka) measured as a percentage deviation from the middle point of the band, while the lower panel depicts the level of Bank of Finland's foreign exchange reserves. The interest rates

Figure 2.2 *Three Key Variables I*
2 January 1987 to 16 March 1989



differentials are measured against the weighted average of foreign interest rates (against the theoretical Ecu interest rate since 7 June 1991). The exchange rate is defined in terms of the trade-weighted currency basket (theoretical Ecu since 7 June 1991). An upward movement in the exchange rate indicates depreciation and a downward movement appreciation.

Figure 2.2 shows that after unrest in the currency markets in the 1986 the renewed confidence in the markka was reflected in substantial capital inflows in early 1987. As a result, interest rates declined and the currency strengthened until the index almost hit the strong edge of the then ± 2¼ per cent band in June 1988. By late 1987, the interest rate differentials had shrunk to less than 2 percentage points from 4 percentage points at the beginning of the year. Throughout the first half of 1987, the Bank of Finland intervened in the foreign exchange market as a buyer in order to restore the exchange reserves to an acceptable level. At the same time, the Bank of Finland intervened in the domestic money market as a seller, which compensated, in part, for the liquidity effects of rising exchange reserves. Without foreign exchange intervention, the currency would have quickly strengthened to the lower edge of its band in the first half of 1987.

In the subsequent three years, the exchange rate fluctuated at around 2 per cent level below the mid-point of the band. The interest rate differentials exhibited relatively large fluctuations around 2 percentage points level until autumn 1989. The exchange rate hit the strong edge of the band immediately before the widening of the band from ± 2¼ per cent to ± 3 per cent in November 1988. This move created room for some further appreciation of the markka. Strong capital inflows continued in the first quarter of 1989 leading to declining interest rates, while the currency index again hit the strong edge of the band in February 1989. The interest rate differential *vis à vis* the average interest rate for the currencies included in the index fell below 1 percentage point in March 1989, the eve of the realignment of the currency band.

On 17 March 1989, the fluctuation range of the currency index was shifted downward by about 4 per cent. As a result the markka strengthened immediately and interest rates rose steeply by about 2 percentage points. Within two weeks the exchange rate was again very close to the strong edge of the realigned band. Despite some decline in interest rates, the interest rate differential *vis à vis* the index currencies remained at a somewhat higher level than before the realignment.

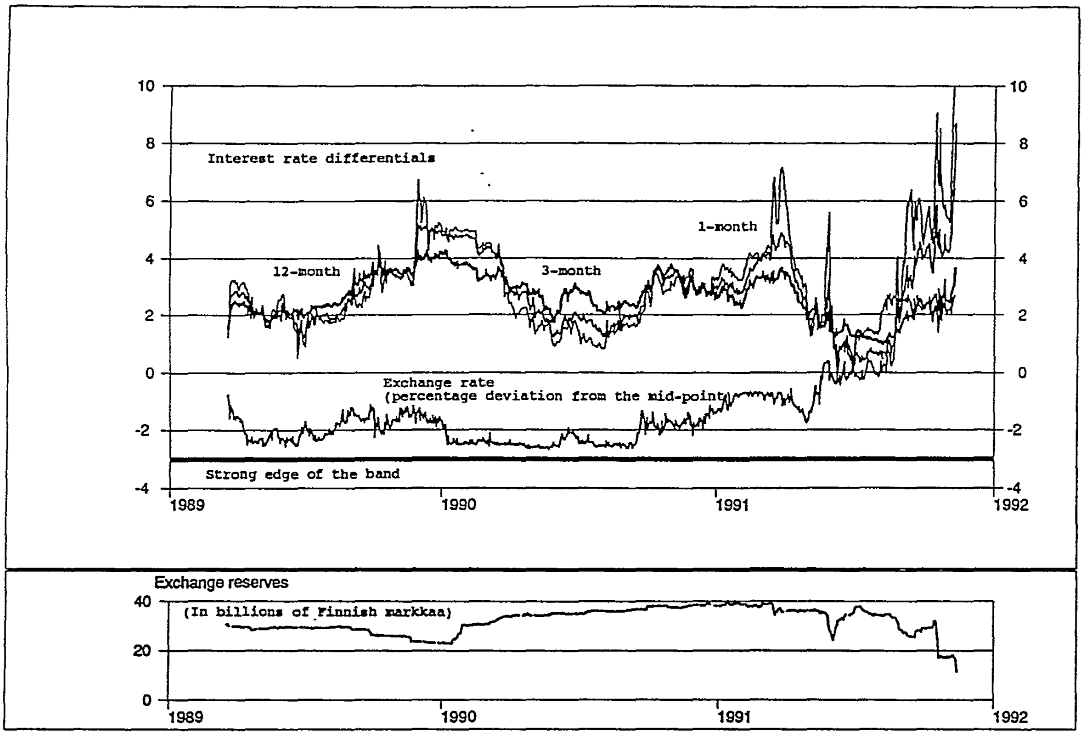
Between March and August 1989, the Bank of Finland did not intervene to any large degree in the foreign exchange market, but it did intervene in the money market for liquidity management purposes. In the autumn the markka was under pressure on three occasions, during which the Bank of Finland lost reserves totalling some FIM 7 billion (USD 1.75 billion), a small amount as such compared to earlier speculative attacks. Because of the uncertainty in the foreign exchange market the interest rate differential widened from a 2 to 2.5 percentage points to a 4 to 6 percentage points, which was sufficient to stop the capital outflow and to prevent a major weakening of the markka.

Confidence was restored in January 1990. Owing to the one-month labour dispute in the banking sector in February, the sharp decline in domestic interest rates was postponed to March/April. In the first half of the year there were heavy capital inflows, which contributed to the strength of the currency and brought the interest rate differential back to its "normal" level of around 2 percentage points. As the currency index remained very close to its lower limit, the Bank of Finland had to intervene in the foreign exchange market as a buyer.

The restoration of confidence proved temporary, however. The weakening of the economy and uncertainty about the national budget led to an expectations-driven upward drift in domestic interest rates in September and October 1990, as a result of which the interest rate gap widened from 2 to around 4 percentage points.

Visual inspection of the data in *Figures 2.2* and *2.3* reveals that each time the 1 and 3-month interest rate differentials have shrunk to around the 1 percentage points level, the exchange rate has shown a tendency to depreciate. Such episodes are observed in late 1987, summer 1988, early 1989, summer 1989 and, again, in summer 1990. On the other hand, when the interest rate differential has stayed at its average level of 2 percentage points or above, the currency has shown a tendency to appreciate. This is especially true in summer 1987, in spring and autumn 1988, and spring 1990. These observations suggest that the interest rate differential that would have kept currency flows balanced for most of the post-1986

Figure 2.3 *Three Key Variables II*
20 March 1989 to 14 November1991



period up to autumn 1990 is somewhere between 1 and 2 percentage points, *i.e.*, ½ to 1 percentage point below the average actual outcome.

Up to 1990, the swings in the the exchange rate and the interest rate differentials exhibit negative, though not very strong, correlation. The main exceptions are early 1987, when the Bank of Finland intervened in the foreign exchange market in order to restore the exchange reserves to an acceptable level, and the period from October 1989 to March 1990, when the markka was under pressure and when the return to "normality" was postponed by the one-month bank strike in early 1990. Since autumn 1990, the correlation has been positive, rather than negative. *Figures 2.2* and *2.3* reveals that both the day-to-day and the month-to-month volatility of interest rate differentials was greater in the period after 1988 than before, whereas the exchange rate volatility has remained roughly constant until mid-1991. The interest rate volatility increased especially in the short end of the maturity structure. The widening of the band by 1.5 percentage points in November 1988 may have contributed to this outcome, although the more likely explanation is the increased uncertainty on the future economic development as the awareness of economic imbalances became more wide-spread. In addition, the discretionary measures by the Bank of Finland in the course of 1989, such as the surprise realignment of the band, the introduction of supplementary reserve requirements on banks and the changes in operational mechanisms of liquidity control aiming at limiting the banks' access to central bank borrowing, all contributed to increased interest rate variability.

Figure 2.4 *Interest Rate Differentials and Exchange Rate*

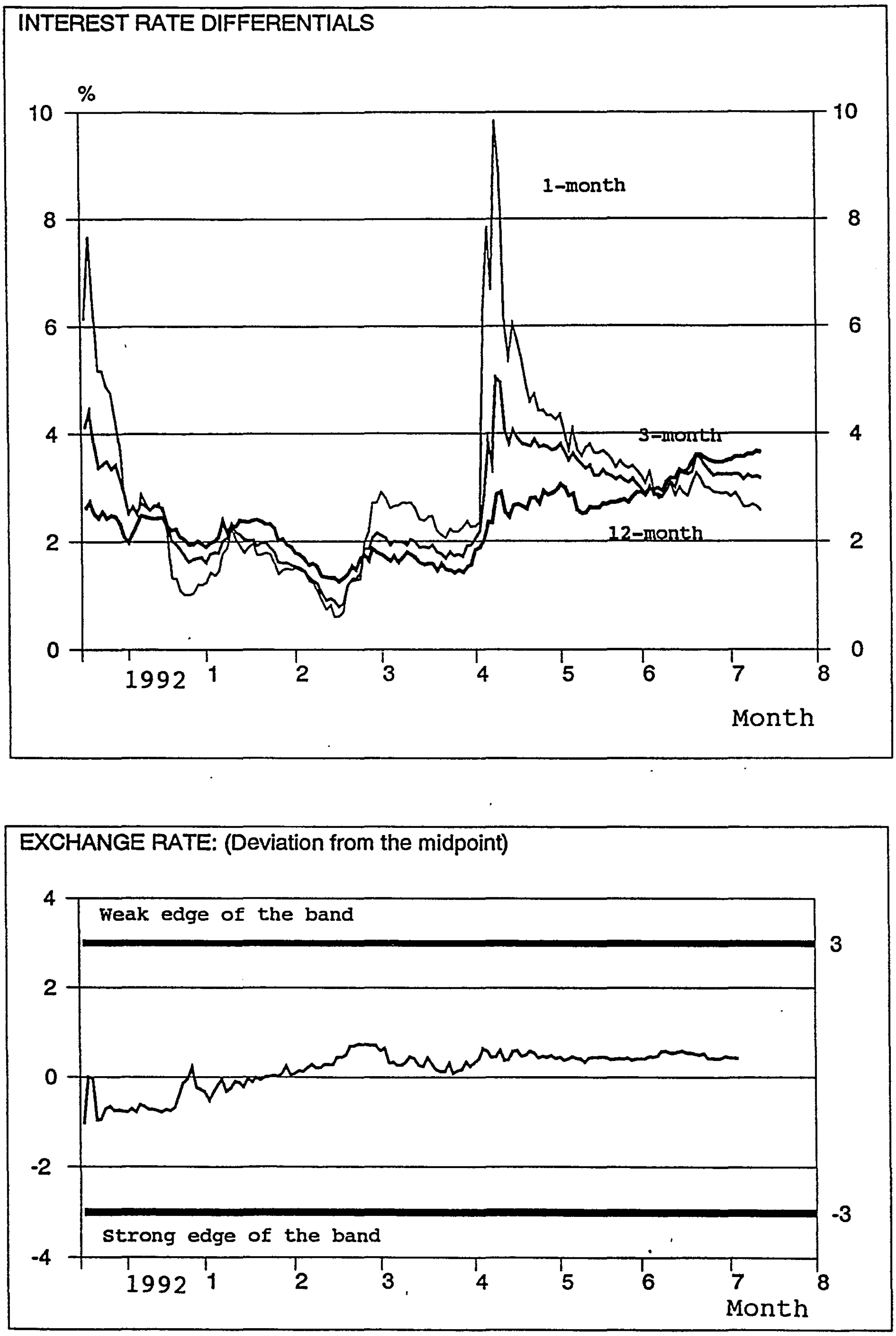


Figure 2.4 depicts the interest rate differential and the exchange rate for the post-devaluation period 18 November 1991 to 31 July 1992. Immediately after the devaluation, the exchange rate was slightly below the mid-point of the realigned band. More recently it has remained fairly stable at a level slightly above the mid-point. The interest rate differentials for 1 and 3-month terms quickly narrowed to

below 2 per cent level, whereas the 12-month differential hardly changed at all compared to the level it had been prior to the devaluation. The brief 'honeymoon' in early 1992, when the interest rate differentials were below the 2 percentage point level, ended abruptly with a new speculative attack in early April 1992. A few months later, the currency was once again came under pressure and yield differentials rose.

That the devaluation was a blow to credibility is not surprising. Although the real depreciation was sufficient to restore export-sector competitiveness (measured by relative unit labour costs in common currency) to a level far above its long-run average, the negative impact of the devaluation on sheltered-sector employment, together with continuing concern about the sustainability of central government deficit, has increased political uncertainty, the cost of which has been reflected in higher interest rates. The Finnish experience is a powerful reminder of the high cost of losing the nominal anchor of the economy.

3 A SELECTIVE REVIEW OF THE LITERATURE

In this section we present a brief review on target-zone literature. Rather than discuss the theoretical structure of the models we focus on the empirical applicability of these models to understanding the Finnish experience of maintaining the currency band over the past six years or so.

Although the target-zone models have several empirical implications relevant to policy, many of the predictions of the theory are, for a number of reasons, extremely difficult to test by rigorous econometric methods. Direct testing is precluded by the impossibility of observing the so-called fundamental process, which is a composite of all factors which affect the overall macroeconomic balance. In some cases, rigorous tests are not even needed for observing discrepancies between data and the predictions of the theory. One further difficulty is that empirical testing of rational expectations models, to which category target-zone models belong, typically involves joint testing of several hypotheses (rational expectations, symmetric information, uncovered interest parity, as well as assumptions about the central banks' intervention rules).

3.1 Basic Target-Zone Model

The standard target-zone models start off with the asset-pricing relationship for the exchange rate (see Krugman, 1991, and Froot and Obstfeld, 1991):

(3.1) $$s(t) = k(t) + \alpha E_t\,[ds(t)]/dt,$$

where $s(t)$ is the logarithm of the spot exchange rate (measured as units of domestic currency per unit of foreign currency). It is determined by the fundamental $k(t)$ and exchange rate expectations through the parameter α.

This model of exchange rate determination is consistent with the flexible-price monetary model under free floating and full capital mobility. Parameter α represents the semi-elasticity of the demand for money with respect to the interest rate. Assuming that uncovered interest rate parity holds, the interest rate differential between domestic and foreign rates is equal to the expected rate of change in the exchange rate $E_t\,[ds(t)]/dt$. In the monetary model, the fundamental can be defined as $k(t)=m(t)+v(t)$, where $m(t)$ is the logarithm of the money supply and $v(t)$ represents positive shocks to the velocity of money, *i.e.*, negative shocks to money demand. A positive shock to money supply or a negative shock to money demand leads to a temporary money market disequilbrium (excess supply), which quickly disappears as market operators exchange domestic for foreign money. The exchange rate increases (domestic currency depreciates) and the domestic price level rises as a result, which restores the equilibrium in the money market.

More complicated macroeconomic structures are also consistent with exchange rate determination as described by eq. (3.1). In principle, the fundamental is a composite of all factors which determine the short-term IS-LM solution to the macroeconomic equilibrium. For instance, any change, such as an increase in government expenditure, or an improvement in the terms of trade, that would shift the IS-curve to the right and raise the domestic interest rate, can be interpreted as a downward shock to $k(t)$ implying, currency appreciation. The outcome will also depend on whether or not a change in some of the determinants of the fundamental affects exchange rate expectations.

The simplest characterization of the behaviour of the fundamental is to assume that it follows a Brownian motion with or without a drift:

(3.2) $$dk(t) = \mu dt + \sigma dz(t).$$

If $\mu \neq 0$ the process has a drift, *i.e.*, the fundamental has a constant rate of change. Otherwise it is driven by random shocks represented by $dz(t)$, where $z(t)$ is a standard Wiener process. In this case, $E_t[dz(t)]=0$, with a constant instantaneous standard deviation σ.

Equation (3.1) can be expressed in the integral form,

(3.3) $$s(t) = (1/\alpha) \int_t^\infty E_t[k(\tau) \mid k(t)]\exp[-(\tau-t)/\alpha]d\tau,$$

where a stable (no bubbles) solution is assumed. The exchange rate depends on future fundamentals discounted by the factor $(1/\alpha)$. Given the Brownian description for the increment in the fundamental and the absence of interventions (free floating), the conditional expectation of the future fundamental at moment τ in eq. (3.3) becomes $E_t[k(\tau) \mid k(t)] = k(t) + \mu(\tau - t)$. With $\mu=0$, the expected future fundamental is equal to the current one. Otherwise the fundamental moves according to the constant rate of drift. Taking this result into account, the exchange rate is simply $s(t)=k(t) + \alpha\mu$.

This is the solution for the exchange rate under free floating. In the target-zone regime free floating is limited to a given range. If the exchange rate reaches either of the limits of its fluctuation range, the central bank is committed to intervene. An intervention is, by definition, a policy measure which affects the $m(t)$-component of the fundamental. The target-zone for the exchange rate implies that the range of the fluctuations of the fundamental is restricted by offsetting changes in $m(t)$. By this policy rule, the stochastic process described by eq. (3.2) becomes a regulated Brownian motion. Assuming that the policy rule is common knowledge and fully credible, it affects the relationship between the fundamental and the exchange rate.

In order to obtain a general solution to eq. (3.1) in the presence of a target zone, let us postulate that the current exchange rate is a function of the current fundamental $s(t) = s(k(t))$. Using Ito's lemma and taking into account eq. (3.2), the exchange rate in eq. (3.1) must satisfy

(3.4) $$s(k(t)) = k(t) + \alpha\mu s_k + \tfrac{1}{2}\alpha s_{kk}\sigma^2.$$

In a credible target zone, the exchange rate is, therefore, a solution to the following function:

(3.5) $$s(k(t)) = k(t) + \alpha\mu + A\exp(\lambda_1 k(t)) + B\exp(\lambda_2 k(t)),$$

where λ_1 and λ_2 are the roots of the characteristic function $\tfrac{1}{2}\alpha\sigma\lambda^2+\alpha\mu\lambda-1=0$. The arbitrary constants A and B are determined by the boundary conditions. In the target zone-model these *smooth pasting conditions* are defined as $s_k(k_u)=s_k(k_l)=0$, where k_u is the upper limit and k_l is the lower limit of the fundamental. Smooth pasting conditions remove the arbitrage opportunity of making one-way bets on the exchange rate as it approaches either of the edges of the target zone.

Assuming a zero drift and a symmetric band, the current exchange rate as a function of the current fundamental is as follows:

(3.6) $$s(k(t)) = k(t) - \sinh(\lambda k(t))/\lambda\cosh(\lambda k_u(t)),$$

where $\lambda=[2/(\alpha\sigma^2)]^{1/2}$.[7] This can be illustrated graphically by the familiar S-shaped curve. The relationship is proportional in the middle of the band and becomes horizontal as it approaches either of the two edges of the band (*cf.* Krugman, 1991, and Svensson, 1991b). Assuming a non-zero drift the drift parameter shifts the curve vertically upwards ($\mu>0$) or downwards ($\mu<0$) by an amount $\alpha\mu$.

The non-linear relationship between the exchange rate and the fundamental implies that, while the fundamental is evenly distributed between the limits of the fundamental band, the exchange rate is more often near the edges of the band than in the middle. The asymptotic distribution of the exchange rate should, therefore, be U-shaped. This holds for a symmetric Brownian process. With a non-zero drift, the distribution may be either L-shaped ($\mu<0$) or J-shaped ($\mu>0$). A related implication is that the asymptotic variability of the exchange rate should decline when the exchange rate approaches the boundaries of the currency band.

The U-shape of the distribution of the exchange rate has not obtained much empirical support. The Swedish data over the period 1982-90 revealed a unimodal exchange rate distribution which was concentrated in the lower half of the band (Lindberg and Söderlind, 1991). More recently, the exchange rate has remained very close to the mid-point of the band. In Norway, the exchange rate fluctuated widely between the two edges of the band until early-1989, but has since remained in the neighbourhood of the mid-point (Mundaca, 1989). Flood *et al.* (1990) examined the exchange rates of six long-term members of the ERM. Using daily data, they divided the EMS period into 13 sub-periods corresponding to ERM realignments and found some weak evidence of the bi-modality of the distribution of the exchange rates within the ERM fluctuation ranges. In the majority of cases, the data were clustered in the middle of the band. Rose and Svensson (1991), examining the FFR/DEM exchange rate during the EMS period, found strong evidence of statistically significant mean reversion of the exchange rate within the band. Svensson (1991a) using broader data from the EMS member countries (6 currencies) for the period, reported similar results.

Using daily data on Finland, Vajanne (1991) observed unimodal distribution of the exchage rate for the period from January 1987 to March 1989 and from March 1989 to June 1991. In the latter period, the distribution was strongly skewed towards the edge of the band. The unimodality of the exchange rate distribution points to mean reversion in the fundamental process. The skewness in the distribution, in turn, may signal the fact that the authorities have defended a narrow, unofficial band located in the lower half of the official band.

The fact that the exchange rate distributions do not seem to resemble those predicted by the basic target-zone model does not imply that the the theory as such is wrong. What it does, however, do is to warn against interpreting the

[7] Sinh and cosh are hyperbolic sine and cosine functions, respectively. These are defined as follows: $\sinh(x)=½[\exp(x)-\exp(-x)]$ and $\cosh(x)=½[\exp(x)+\exp(-x)]$.

empirical implications of the first-generation target-zone models as realistic statements about the real world.

3.2 *Intramarginal interventions*

One of the weaknesses of the basic target-zone model is the assumption that the authorities intervene only when the fundamental reaches the edge of the band. There is substantial empirical evidence that movements of exchange rates within the band display strong mean reversion, which may be caused, *inter alia*, by intramarginal interventions. As a matter of fact, intramarginal interventions seem to be the rule rather than the exception in the majority of EMS countries. This is not surprising. After the 1987 Basle/Nyborg Agreement, the ERM participants introdeced to more flexible operational practices by accepting wider use of intramarginal interventions. Some ERM countries, Belgium and the Netherlands, apply a voluntary band *vis à vis* DEM, which is much narrower than the one implied by the ERM rules. This practice is consistent with the observations on exchange rate distributions referred to above.

These findings have led to the development of target-zone models that take intramarginal interventions into account. The implementation of potentially plausible intervention rules is, however, constrained by the fact that it is difficult, if not impossible, to find closed-form solutions similar to eq. (3.6) when the fundamental follows more complicated processes. As shown by Delgano and Dumas (1992) and Froot and Obstfeld (1991), such a solution can, however, be found in the case where the fundamental follows a mean reverting process

$$df(t) = -(1-\beta)[f(t)-f_0]dt + \sigma dz, \qquad (3.7)$$

where f_0 is the reversion point of the fundamental towards which it would converge in the absence of stochastic shocks. In discrete time, eq.(3.7) would take the form $f(t+1)=(1-\beta)f_0+\beta f(t)$. This 'partial adjustment' equation has a finite reversion point if $0<\beta<1$. The corresponding reversion point of the exchange rate is $s_0=s(f_0)$. This could be interpreted as the central bank's preferred level for the exchange rate. While accepting temporary deviations, the central bank intervenes in order to steer the exchange rate towards the preferred level, thereby smoothing fluctuations in the exchange rate.

This policy rule is equally applicable to managed floating and to target zones. In the latter regime, the presence of mean reversion in the fundamental reduces the nonlinearity (S-shape) in the relationship between the fundamental and the exchange rate (*cf.* Lindberg and Söderlind, 1992). The exchange rate distribution becomes unimodal around s_0.

An interesting, but analytically more difficult, situation arises if the central bank does not aim at exchange rate smoothening as such, but instead aims at policy activism by changing from time to time the position of the exchange rate target inside the official band. In other words, the central bank defends a narrow unofficial band, which has soft edges and the position of which may change. The obvious difficulty in attempts to use limited policy autonomy with the help of bands within official bands is that market participants quickly learn the intervention policy rule. As a result, such intervention policy may prove to be counterproductive. For instance, when the markets have learned the unofficial band and believe that the central bank is likely to defend it for some time but not for ever, short-term interest rates may decline, even if the exchange rate is near the strong edge of the band, whereas longer-term rates may actually rise because of the expectation that the defence point will shift up in the future.

Although in theory the band can be used for limited monetary policy activism to counteract the effects of various shocks to the economy, this may prove extremely difficult to achiev in practice. It would appear, as argued by Gros (1990), that the success of policy activism by using the potential room for manoeuvre provided by the limited exchange rate flexibility within the band depends entirely on whether or not fiscal policy is consistent with monetary policy.

3.3 *Term Structure of Interest Rates*

In the same manner as the current exchange rate can be expressed as a function of the current fundamental, *cf.* eq. (3.6), the future exchange rate can be expressed as a function of the future fundamental (Svensson, 1991b). Assuming uncovered interest parity, the interest rate differential for an arbitrary term τ is accordingly[8]

$$(3.8) \qquad \delta_\tau(k(t)) = [\mathrm{E}_t[s(k(t+\tau))] - s(k(t))]/\tau.$$

The term τ has a dimension of a unit of time (*e.g.* a month, and it determines the dimension of the interest rate (monthly interest rate). Because the exchange rate is bounded to remain inside the (fully credible) band, the interest rate differential approaches zero as the term τ approaches infinity.

Computation of the interest rate differential for an arbitrary maturity would be easy if the expected future exchange rate inside the band were easily computable. This is, however, not the case. The problem arises from the non-

[8] This holds approximately, because the expected rate of change in the exchange rate is defined as a logarithmic difference, whereas the interest rate differential is defined in terms of basis points (hundreth of a percentage point).

linearity of the relationship between the fundamental and the exchange rate, which implies that $\mathbf{E}_t[s(k(t+\tau))]$ is not equal to $s(\mathbf{E}_t[k(t+\tau)])$, except for infinite term, in which case the expected future fundamental is equal to its unconditional mean (*i.e*, the middle of the fundamental band in the absence of a drift). For all other non-zero terms the expected future exchange rate depends on the length of the term, in addition to the current fundamental.

By applying a similar kind of smooth pasting condition as above, the expected exchange rate can be expressed as a function of the current fundamental and the term (Svensson, 1991b)[9]. The relationship has an S-shaped form similar to that of the relationship between the current fundamental and the current spot rate. The relationship becomes flatter and more linear as the term increases and is horizontal for an infinite term. The difference between the expected exchange rate and the current spot rate can be translated into the interest rate differential by dividing it by the length of the term. The relationship between the currrent exchange rate and the interest rate differential is negative and becomes flatter as the term increases.

Svensson's result depends on the assumption that the fundamental follows a Brownian movement. The implications regarding the term structure of interest rates also apply when allowance is made for a constant drift or a constant devaluation risk. It also holds for the case where the exchange rate is mean reverting as a result of intramarginal interventions and the reversion point is constant (Lindberg and Söderlind, 1992). Difficulties are likely to arise if the fundamental is allowed to make jumps.

Empirical evidence on the negative relationship between the exchange rate and the interest rate differential is scarce. In fact, there is more evidence on the opposite (positive) relationship, although the results tend to depend on the exact time period chosen for empirical analysis (see Section 4.3 below). Bertola and Svensson (1991) provide a possible theoretical explanation for these mixed empirical results. They show that depending on the relative variability between the devaluation risk and the fundamental almost any pattern of observations between the interest differential and the exchange rate can emerge. A low variability of the devaluation risk relative to the fundamental implies a negative correlation between the interest rate differential and the exchange rate, whereas the opposite situation may cause the correlation to become positive.

9 Assuming risk neutrality, the expected future exchange rate is equal to the forward exchange rate.

3.4 *Time-Varying Devaluation Risk*

As stated above, it does not require rigorous econometrics to establish the fact that the central bank generally does not respect the assumption of intervening marginally at the edges of the band alone. Neither does it require any in-depth study to learn that many countries have, at least occasionally, suffered from serious lack of credibility. An interesting question, therefore, is whether the lack of credibility is quantifiable in some way.

Bertola and Svensson (1991) have suggested the following procedure for measuring the devaluation risk. Let $s(t)$ stand for the log exchange rate and define $e(t)$ as its deviation from the mid-point c of the band, $e(t)=s(t)-c$. The expected change in the exchange rate is thus

$$\mathbf{E}_t[s(t+\tau)]-s(t) = \{\mathbf{E}_t[e(t+\tau)]-e(t)\}+\mathbf{E}_t[\Delta c]. \tag{3.9}$$

The first term on the right-hand side (within the brackets) represents the expected depreciation inside the band between the dates t and $t+\tau$, whereas the latter term represents the devaluation risk, *i.e.*, the expected change in the mid-point of the band. The latter is denoted by $g(t)$. Let $\delta_\tau(t)$ stand for the interest rate differential (at term τ) between domestic and foreign interest rates. Assuming uncovered interest parity, the devaluation risk can now be written as follows:

$$g(t) = \delta_\tau(t)-\{\mathbf{E}_t[e(t+\tau)] - e(t)\}/\tau. \tag{3.10}$$

The interest rate differential is observable data, but the expected depreciation inside the band is not. Several authors, including Bertola and Svensson (1991), have attempted to estimate the expected exchange rate inside the band by using autoregressive models. This is consistent with the assumption of a mean-reverting fundamental, such as the one expressed in eq. (3.7). Once one has an estimate, or a plausible proxy, for the expected depreciation inside the band, computation of the perceived devaluation risk is straightforward.

Rose and Svensson (1991) were the first to implement the Bertola-Svensson model. These authors study the FRF/DEM target zone over the period March 1979 to May 1990. For the same period, Svensson (1991a) extends the procedure to five other EMS currencies. Frankel and Phillips (1991) update the test for EMS exchange rates using a survey of exchange rate forecasts in addition to interest rate differentials in measuring exchange rate expectations. All these studies support the view that the credibility of the EMS has improved during recent years.

Vajanne (1991) estimated time-varying devaluation risk with the Finnish data using an autoregressive proxy for the expected depreciation inside the band. As expected on the basis of ealier studies (or simply by observing data on interest rate differentials), the Finnish currency band has lacked credibility most of the time, although for the period before autumn 1989 the result may have been affected by changes in the reversion point of the targeted exchange rate inside the band. Similar results were found by Lindberg, Svensson and Söderlind (1991) for the Swedish currency band.

In a later study Vajanne (1992) made an attempt to explain the devaluation risk of the Finnish markka by a selected macroeconomic variable. Lindberg *et al.* (1991) made similar experiments with Swedish data. According to the results by Vajanne, the rate of unemployment has a positive effect on the computed devaluation risk, whereas the rate of growth of GDP, the level of foreign exchange reserves and an improvement of the current account all have a negative effect. The rate of growth in the money supply and the real exchange rate, in turn, were found to be statistically insignificant.

4 SOME EMPIRICAL RESULTS

4.1 Simplest Test of Band Credibility

In the following we continue our descriptive analysis by attempting to quantify the credibilty of the currency band. The method is described in Svensson (1990). The credibility of the Finnish currency band has previously been examined using this method in Kontulainen *et al.* (1990) and Geadah *et al.* (1992). Although the method can be used to identify periods when there was an acute lack of credibility, it is insufficient to make any conclusions about whether and when the band has been fully credible.

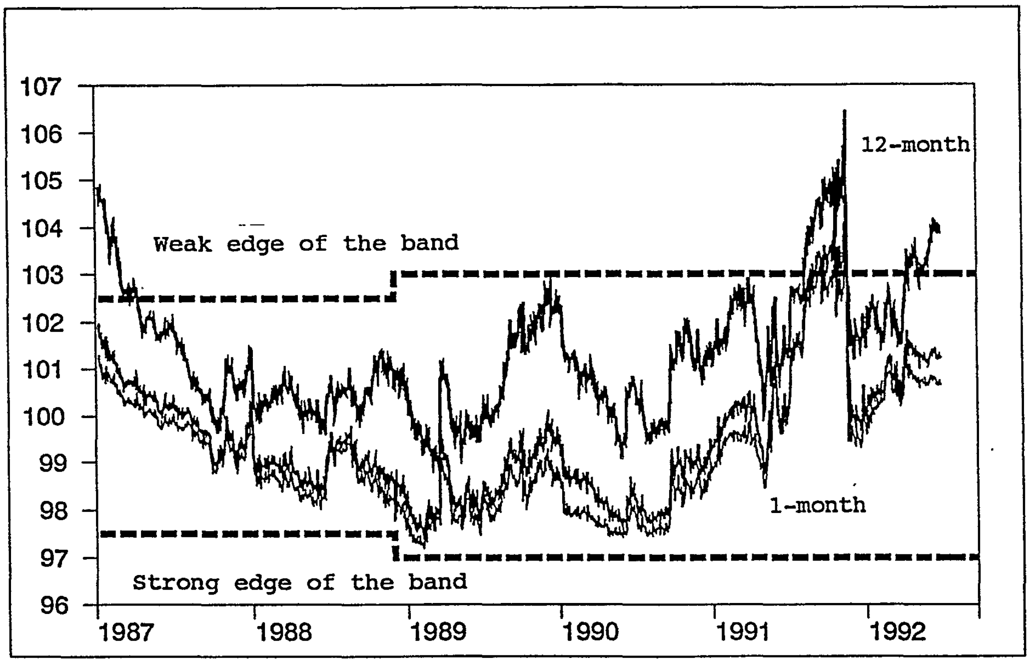
The results are presented in *Figure 4.1*. It presents data on the spot exchange rate as well as the computed forward exchange rate for 1, 3 and 12-month terms. The computation is based on the following formula

(4.1)
$$\begin{aligned} f_\tau(t) &= s(t)[(1 + i_\tau(t)\tau)/(1 + i^*_\tau(t)\tau] \\ &\approx s(t)(1 + i_\tau(t)\tau - i^*_\tau(t)\tau), \end{aligned}$$

where $s(t)$ is the current spot rate, $i_\tau(t)$ is the domestic and $i^*_\tau(t)$ the foreign interest rate, and τ is the term (in years). The interest rates are expressed as straight annualized rates. The foreign interest rate is LIBOR and the domestic rate HELIBOR adjusted for a 360 day year (instead of 365 days). The spot rate is defined in terms of the currency index (since 7 June 1991 in terms of the Ecu) with the mid-point of the band being indexed to 100. For the Ecu-period, the market Ecu spot rate and the market Ecu interest rate are used instead of their theoretical (basket) counterparts.

Assuming uncovered interest parity and a credible band, $f_\tau(t)$ is between the upper and lower edges of the band. Otherwise there would be unexploited arbitrage opportunities if the band were credible. We can thus conclude that if $f_\tau(t)>s^u$, the weak edge of the band, it is perceived that there is a high probability of a devaluation, and if $f_\tau(t)<s^l$, the strong edge of the band, it is perceived that there is a probability of a revaluation. The test is inconclusive when $s^l<f_\tau(t)<s^u$. The reason for inconclusiveness is that, while the interest rate differential reflects exchange rate expectations, uncertainty implies that there is a probability distribution around the mean. Incomplete credibility would imply that this distribution goes beyond one of the edges of the band, even though the mean may remain inside.

Figure 4.1 *Computed Forward Exchange Rate*



Examining the graphs in *Figure 4.1* reveals that the computed forward exchange rate has remained inside the band for most of the time. The 12-month forward rate was above the weak edge in early 1987. From autumn 1987 to mid-1990 the 12-month forward rate fluctuated slightly above the mid-point. In autumn 1989, the rate approached the weak edge. From autumn 1990 onwards, the forward rates were on a rising trend, reflecting movements in the spot rate. In July 1991, the 3 and 12-month forward rates passed the weak edge, while the 1-month rate just hit the limit. Since the November 1991 devaluation, the computed 12-month forward rate has remained very close to the weak edge of the band, passing the limit again in April 1992.

These observations are in accordance with the preliminary conclusions made in *Section 2*. The interest rate differentials started to widen in autumn 1989, and this was more pronounced in longer maturities. The policy which allowed the exchange rate to remain near the strong edge of the band for a number of years may in itself have created expectations of a future relaxation. Although the March 1989 revaluation did not have a major impact on interest rate differentials in the short term, it may have created expectations of a future reversal, thus undermining band credibility.

Figure 4.2 *5-Year Forward Exchange Rates*

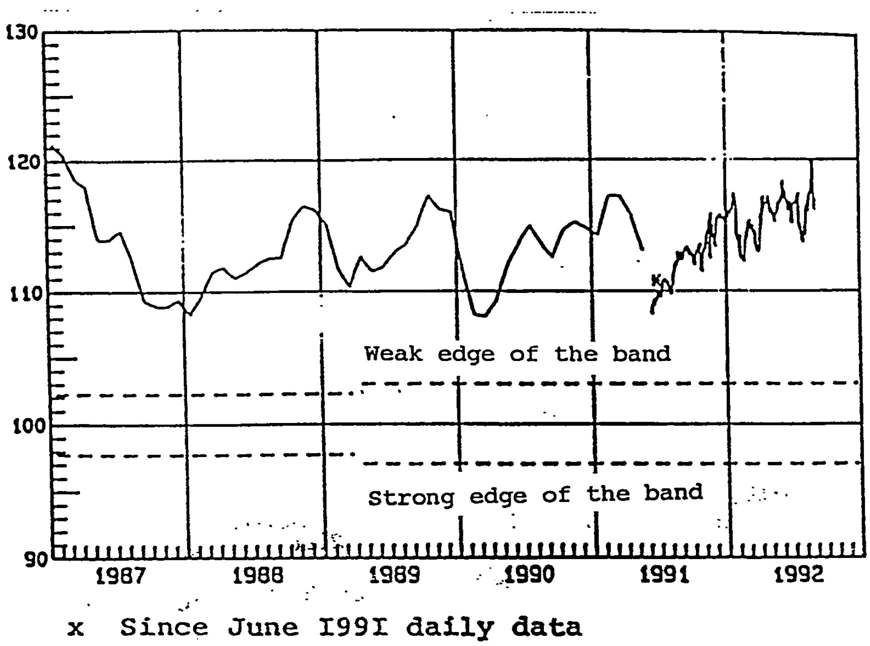


Figure 4.2 depicts similar data computed for the 5-year term. For the domestic interest rate we used a 5-year government bond yield. Data are monthly up to the pegging to the Ecu and daily thereafter. Because of lack of data on long-term bond interest rates in some countries whose currencies were included in the Finnish trade-weighted currency index, we used the 5-year Ecu bond rate as a proxy for a basket bond yield. The currencies making up the Ecu represented about 50 per cent of the currencies in the currency index.

The 5-year forward rate for the markka has constantly been above the weak edge of the band. In 1988-1990, the computed 5-year forward rate (measured in terms of the index) fluctuated between 110 and 115. The blow to credibility brought about by the devaluation in November 1991 is reflected in the size of the gap, which immediately rose from 112 to 115 and subsequently to 120 in July 1992. Part of the gap can be attributed to the poor liquidity of the bond market in Finland, which introduces a liquidity premium in to effective yields, but this does not alter the conclusion concerning the lack of long-term credibility.[10]

[10] Assuming that the liquidity premium is 75 basis points in the effective yield to maturity, this would lower the computed 5-year forward rate by only 4 percentage points.

Comparing these observations with similar data from Denmark, Norway and Sweden reveals interesting differences and similarities (see Geadah *et al.*, 1992). The computed 12-month forward exchange rate for Denmark remained between 2.5 and 5 per cent above the upper limit of the DEM band of the Danish krone until 1990, but has since remained inside, although close to the weak edge. Computed for the 5-year term, the forward rate for the Danish krone has been above the the weak edge, although the gap has narrowed rapidly from year to year. In Norway the test reveals lack of credibility until early 1989, whereafter the forward rates up to the 12-month term have been safely inside the band. This improvement in credibility coincides with a change in policy: until early 1989 the exchange rate was allowed to move fairly freely between the boundaries of the ±2¼ per cent band, but since than after it has been kept fairly constant in the middle of the band. The record is even more striking for the 5-year term. As a result of the 1986 devaluation, the computed forward rate was more than 20 per cent above the weak edge of the band in 1978, but by 1990 this gap had disappeared. For Sweden the computed forward rates generally remained inside the the Swedish ±1½ per cent band until autumn 1989, since when the 12-month forward rate has been above the upper limit. The credibility problems in Sweden have thus arisen at about the same time as in Finland. The 5-year forward rate for the Swedish krona has remained outside the upper limit by a margin of around 9 per cent. The Swedish situation has improved since 1990, whereas in Finland the course of development has been the opposite.

4.2 Intramarginal Interventions

Since changes in the interest rate differential have an impact on either the exchange rate or the foreign exchange reserves, exchange rate policy can no longer be separated from domestic monetary policy. Exchange rate movements can be steered either through open market operations or directly through spot interventions in the foreign exchange markets. The choice of the type of intervention depends on, *inter alia,* how quickly the desired effect on the exchange rate or interest rates is needed. If an immediate impact on the exchange rate is needed, interventions are carried out in the foreign exchange market. On the other hand, if the central bank wants to steer interest rates via banks' free reserves (liquidity), open market operations in the domestic money market are normally carried out.

It is clear from the discussion in *Section 3* that intramarginal interventions have been the rule rather than the exception in Finland. As a matter of fact, there have been no interventions which have coincided exactly with the edges of the official band. In November 1988, the exchange rate went beyond the strong edge just before the band was widened from ±2¼ to ±3 per cent. On the other hand, the

Bank of Finland has frequently intervened when the exchange rate has reached a level which is around ½ percentage point from the edge of the band. This occurred on a number of occasions near the strong edge in 1989 and 1990. In late 1991, the same occurred near the weak edge of the band.

Table 4.1 gives aggregated quarterly information on the frequency and average size of daily interventions by the central bank in the spot exchange market.[11] In 1987, central bank purchases dominate sales. The years 1988 and 1989 were dominated by days when no intervention occurred (90 per cent of all days). The third quarter of 1988 stands out as a period when repeated sales occurred, whereas purchases dominated sales in the first half of 1990. Interventions were more frequent in 1991, with sales dominating purchases both in terms of frequency and amounts transacted.

In *Figure 4.3* we look at intramarginal interventions from a different perspective. Instead of the size of interventions, attention is paid to their timing as well as to the point at which an intervention takes place. The figure shows the course of the actual exchange rate, $e(t)$, measured as a percentage deviation from the mid-point of the band. The two additional variables are defined as follows:

$$e^P(t) = e(t\text{-}j) \text{ if previous central bank spot purchase is on day } t\text{-}j$$
$$e^S(t) = e(t\text{-}j) \text{ if previous central bank spot sale is on day } t\text{-}j.$$

The corresponding graphs in *Figure 4.3* indicate the levels at which the Bank of Finland has stepped in, either buying or selling foreign exchange in the spot market. The upper line indicates the level of the spot exchange rate at which the Bank of Finland has sold foreign currency in order to stop the upward movement or, at least, to resist ongoing depreciation of the markka within the band. The lower line, in turn, indicates the dates and the points at which the central bank has bought foreign exchange in the spot market.

The new variables are introduced in order to take into account the fact that, in so far as central bank interventions have a signalling effect, they should affect short-term exchange rate expectations. For instance, if an upward movement has been stopped once or twice at a certain point this is likely to increase the probability, as perceived by market makers, that the central bank will intervene at around the same point in the future as well. This is equivalent to saying that the market learns to think that there is an implicit band which the central bank will defend at least temporarily, although there may be much uncertainty about the exact level of future intervention points (soft edges of an implicit band).

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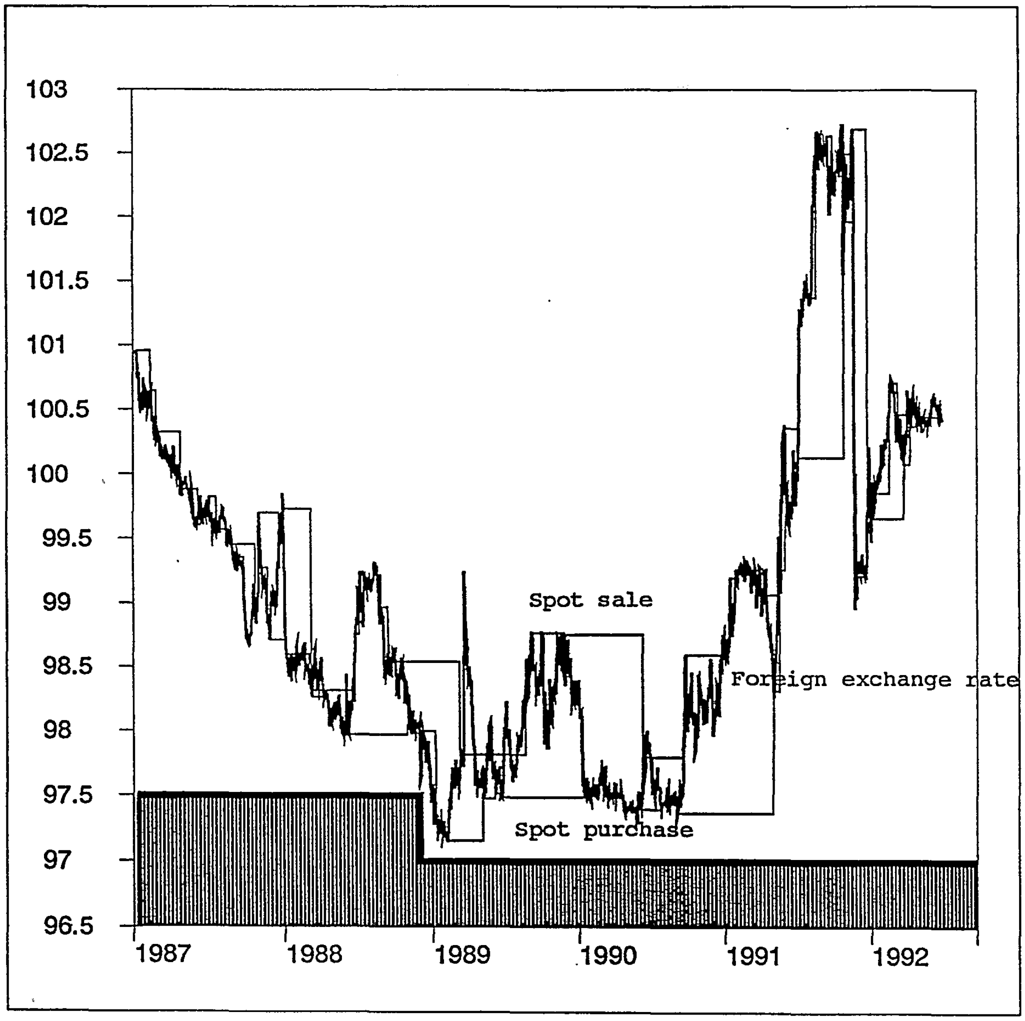
[11] Daily data on foreign exchange interventions by the Bank of Finland is not published. Since April 1990, data have been published on a weekly basis in the Bank of Finland statistical review (*Financial Markets*).

Figure 4.3 *Exchange Rate and the Intervention Points*



There is plenty of anecdotal evidence that this signalling mechanism has, indeed, worked in the past. Although the size of central bank interventions is not known exactly, dealers, being counterparties to the central bank, know when the central bank has been in the market. This is all that is needed for a signalling effect. Non-dealer participants, who are active in the market and customers of dealers, quickly learn from the latter. Because financial journalists are typically in daily touch with dealers, everyone else has a change to learn about an intervention the next morning from financial press.

Visual inspection of *Figure 4.3* confirms the observations made above. In 1987, interventions were frequent and mostly on the purchasing side, although the frequency of intervention started to diminish towards the end of the year. This indicates that the central bank was leaning against the wind by resisting the pressure towards appreciation in order to build up exchange reserves. The three subsequent years were characterized by relatively infrequent spot interventions, while the exchange rate fluctuated near the strong edge of the official band. In summer 1991, the exchange rate (now defined in terms of the Ecu) shot up close to the weak edge of the band. The move was resisted by spot sales in late

Table 4.1 *Average Frequency and Size of Intervention*

		Number of days			Average amount (FIM bill)	
		Purc-hases	Sales	None	Bought	Sold
1987	Q1	35	3	25	217	18
	Q2	24	3	34	237	24
	Q3	21	5	40	230	11
	Q4	9	8	47	168	141
1988	Q1	6	1	57	212	3
	Q2	17	1	44	236	216
	Q3	0	17	49	-	327
	Q4	6	0	57	180	-
1989	Q1	11	5	47	487	441
	Q2	3	0	60	160	-
	Q3	0	7	58	-	500
	Q4	0	1	61	-	1730
1990	Q1	28	0	36	358	-
	Q2	16	1	44	187	320
	Q3	4	3	58	110	293
	Q4	-	2	60	-	1170
1991	Q1	0	27	35	-	539
	Q2	16	10	36	631	1397
	Q3	4	29	33	620	476

summer. The fact that a temporary strengthening was stopped by purchases on a few occasions probably signalled that the central bank was aiming at a point around the mid-point immediately before the pegging to the Ecu.

The data in *Figure 4.3* conceal two discontinuities in the data. The exchange rate seems to jump in March 1989. This is a result of the fact that the exchange rate is measured as a percentage deviation from the mid-point. In reality, the exchange rate immediately appreciated by about 3 per cent. Similarly, the apparent downward jump in the exchange rate associated with the November 1991 devaluation shows that the relative position of the exchange rate moved close to the mid-point of the new band after being close to the weak edge in the old one. The level of the exchange rate itself rose by 10 to 11 per cent.

In Section 4.4. below, we use this information, together with information on the total volume of interventions affecting liquidity and on the interest rate differential in order to construct a proxy for the expected future exchange rate inside the band. This proxy is then used to compute an estimate of the perceived devaluation risk following the procedure described in Section 3.4.

4.3 Interest Rate Differential and the Exchange Rate

One of the main implications of Svensson's (1991b) analysis is that the interest rate differential should be a negative function of the current exchange rate. The intuition is straightforward. If the band is credible and the exchange rate is close to the strong edge of the band, the expected future level of the exchange rate is somewhere above its current level. The implied expected depreciation is reflected in the interest rate differential; the domestic interest rate is above the foreign interest rate by an amount equivalent to the expected depreciation. The same applies symmetrically for the case where the current level of the exchange rate is close to its weak edge: the implied expected appreciation drives the domestic rate below the foreign rate.

The empirical evidence on the negative correlation between the exchange rate and the interest rate differential is mixed and highly dependent on the time period examined. Svensson (1991b) used monthly Swedish data for the period from February 1986 to October 1989. The results were broadly consistent with the above-mentioned implications of the theory regarding the negative relationship between the exchange rate and the interest rate differentials as well as the term-structure of interest rates. The negative slope of the estimated linear relationship declined as the length of the term increased (1, 3, 6 and 12-month and a 5-year terms were experimented). In addition, the standard deviations of the interest rate differentials were decreasing in term, as predicted by theory. The statistical properties of the estimated model pointed to misspecification.

The constant term in the empirical relationship was positive, which may reflect either the positive drift in the fundamental or the devaluation risk. It is apparent that Svensson's results depend, to large extent, on the particular period used in estimation. This was a period when there was no major uncertainty in the market, and the SEK index remained mostly within the lower (strong) half of its ± 1½ per cent official band. As shown by Lindberg and Söderlind (1991), quite a different conclusion emerges when the data set is extended beyond the relatively short and relatively calm period used by Svensson. They used daily data covering the period from January 1982 to mid-November 1990, which revealed positive correlation between the exchange rate and the interest rate differential.

The study by Kontulainen *et al.* (1990) used daily and weekly data on Finland covering the period from October 1987 to the eve of the March 1989 revaluation. The period was *intentionally* restricted to one which was characterized be comparatively small interest rate differentials and by the absence of major uncertainty in the market. The correlation between the interest rate differential and the exchange rate was found to be negative in most cases. The interest rate differentials for four different terms (1, 3, 6 and 12-months) were regressed on the constant term and the exchange rate (measured as a percentage deviation from the middle point). The widening of the band in November 1988 was taken into account by a dummy variable. Except for the dummy, the specification was thus the same linear approximation of the theoretical model as used by Svensson.

The slope coefficients were all negative and significantly different from zero, as the theory predicts. However, the slope did not decline as the term increased; rather, it increased, which is in conflict with the theory. As in Svensson's study, the fit was comparatively poor and the serial correlation of the residuals remained large. The constant term was positive and highly significant pointing to the devaluation risk.

Vajanne (1991) examined the robustness of these results by extending the estimation period to include the full year 1987 and to cover all days from the March 1989 revaluation to early June 1991, when the markka's peg was switched from the trade-weighted index to the Ecu. The data were divided into two sub-periods, the break-off point being the revaluation of the markka on 17 March, 1989. In contrast to Kontulainen *et al.*, the correlation between the exchange rate and the interest rate differential was found to be significantly positive for both sub-periods and for all four terms examined.

As noted in *Section 2* there have been repeated episodes of currency unrest since autumn 1989. Thus positive correlation is not a surprise in so far as the latter period is concerned. Positive correlation in the case of the former subperiod, which differs from that used by Kontulainen *et al.* only in that it is nine months longer is, however, somewhat surprising. A likely explanation is that the Bank of Finland intervened heavily during the first half of 1987 in order to restore the official reserves to the level they had been before the 1986 upheaval.

Table 4.2 presents the summary statistics on the exchange rate and the interest rate differential for maturities of 1, 3 and 12-months in three subperiods for Finnish data. The first subperiod stretches from 1 October 1987 to 15 March 1989, that is, to the eve of the revaluation of the markka. The second period covers the post-revaluation period up to the middle of May 1991. Finally, the third subperiod covers the data from the 1989 revaluation to the eve of the 1991 devaluation. The data used are weekly (Wednesdays).

Taking into account the previous empirical findings with Finnish data and the basic statistics presented in *Table 4.2*, we can conclude that for a given period the Finnish data exhibit some of the properties predicted by the basic model. In the first subperiod the interest rate differentials and the exchange rate have negative correlation. This is evident especially for the 3-month and 12-month terms.[12] For 1-month term correlation is negligible. Negative correlation disap-

12 The correlations are of the same order of magnitude when daily or monthly (every fourth Wednesday) data are used instead of weekly data (Wednesdays). The correlations are positive when the first three quarters of 1987 are included in the sample.

Table 4.2 *Basic Statistics (Wednesday Data)*

1 October 1987 to 15 March 1989	Mean	Std	Min	Max	22 March 1989 to 15 May 1991	Mean	Std	Min	Max
e(t)	-1.60	0.60	-2.83	-0.20		-1.89	0.61	-2.62	0.32
δ(t,1)	1.63	0.48	0.38	2.45		2.93	1.35	0.83	7.11
δ(t,3)	1.69	0.49	0.75	2.74		2.91	1.04	1.23	5.12
δ(t,12)	1.98	0.56	0.97	3.18		2.88	0.64	1.37	4.23

Correlations

	e(t)	*δ(t,1)*	*δ(t,3)*	*δ(t,12)*	*e(t)*	*δ(t,1)*	*δ(t,3)*	*δ(t,12)*
e(t)	1				1			
δ(t,1)	-0.04	1			0.47	1		
δ(t,3)	-0.42	0.86	1		0.31	0.94	1	
δ(t,12)	-0.60	0.60	0.89	1	0.12	0.72	0.87	1

22 March 1989 to 13 November 1991

	Mean	Std	Min	Max
e(t)	-1.25	1.50	-2.62	2.67
δ(t,1)	3.03	2.05	-0.26	17.04
δ(t,3)	2.85	1.28	0.43	8.71
δ(t,12)	2.68	0.76	1.03	4.23

Correlations

	e(t)	*δ(t,1)*	*δ(t,3)*	*δ(t,12)*
e(t)	1			
δ(t,1)	0.29	1		
δ(t,3)	0.09	0.93	1	
δ(t,12)	-0.39	0.56	0.79	1

pears after autumn 1989 when confidence became a problem. However, when the post-revaluation data are extended to include autumn 1991, the correlation is again negative for the 12-month term, but positive for the 1-month and the 3-month term.

These findings are broadly consistent with the argument presented by Bertola and Svensson (1991). If the volatility of the devaluation risk relative to the volatility of the fundamental has risen since 1989 then a positive correlation between the exchange rate and the interest differential is to be expected.

In Svensson's model with a constant devaluation risk and in the absence of intramarginal interventions, the stocahstic movements in the fundamental move the exchange rate inside the band, which, in turn, affects the interest rate differential. The causality runs from the exchange rate to the interest rate differential through the expectations mechanism built in the band.

The observation of a negative correlation in itself does not establish causality. In the case of intramarginal interventions the causality may run in the opposite direction. As discussed in *Section 2.3.*, open market operations by the central bank affect the liquidity of the banking system, which has an impact on domestic short-term interest rates and thereby on the interest rate differential. A change in the interest rate differential, in turn, affects capital movements and thereby either the exchange rate or the exchange reserves.

In order to shed some light on this question we estimated two versions of the relationship between the exchange rate and the interest rate differential using weekly (Wednesday) data from the period of relative tranquility, that is, 1 October 1987 to 15 March 1989. We first regressed $\delta(t;\tau)$ on $e(t)$ as suggested by Svensson, and then we regressed $e(t)$ on $\delta(t,\tau)$. The results are presented in *Table 4.3.*

When the interest rate differential is used as the dependent variable, the constant term is around unity. According to Svensson's model, this should be interpreted as a (constant) perceived devaluation risk (per cent per annum). Adding a dummy for the widening of the band in November 1988 reduces the constant term by around half a percentage point, except for the 12-month term. The slope is increasing in the term, which is contrary to the predictions of the model. One explanation for this ordering of the slope coefficients could be the intramarginal interventions and the implied soft-edged unofficial band. This unofficial band may be more credible in a short horizon (three months) than in the longer run (twelve months). As can be seen in the lower panel of *Table 4.3*, it is, however, the latter regression which performs better. Therefore, the causal explanation implied by Svensson's model can be questioned.

In order to assess the causality between the variables we carried out standard Granger-Non-Causality tests for 1-month, 3-month and 12-month terms. This was done by regressing $\delta(t,\tau)$ on its own distributed lags as well as on the distributed lags of $e(t)$ and by regressing $e(t)$ on its own distributed lags and on the distributed lag of $\delta(t,\tau)$. The F-test was used to test the non-causality.

The tests were carried out with and without allowance for simultaneous causality. The results are presented in *Table 4.4*. The hypothesis that the exchange rate is *not* a Granger-cause of the interest rate differential can be rejected at the 5 per cent significance level only in the the case of the 1-month maturity. The hypothesis that the interest rate differential is *not* a Granger-cause of the exchange rate cannot be rejected in any of the examined cases. Simultaneous causality cannot be rejected in the latter period. In the first period there is weak evidence of simultaneity in the case of 1-month term.

Table 4.3 *Interest Rate Differentials and the Exchange Rate (Wednesday data)*

1 October 1987 to 15 March 1989

$\delta(t;\tau) = a + b\,e(t)$

	$\tau = 1$	$\tau = 3$	$\tau = 12$
a	**1.205** (6.1)	**0.863** (4.7)	**1.002** (5.4)
b	**-0.345** (-2.5)	**-0.576** (-4.5)	**-0.626** (-4.8)
Dummy	**-0.573** (-2.9)	**-0.388** (-2.1)	**-0.067** (-0.3)
	R^2=0.106	R^2=0.252	R^2=0.395
	DW=0.48	DW=0.39	DW=0.28

$e(t) = a + b\,\delta(t;\tau)$

	$\tau = 1$	$\tau = 3$	$\tau = 12$
a	**-0.974** (-5.9)	**-0.737** (-5.0)	**-0.643** (-4.1)
b	**-0.237** (-2.5)	**-0.385** (-4.5)	**-0.392** (-4.8)
Dummy	**-1.144** (-10.1)	**-1.004** (-9.6)	**-0.854** (-7.7)
	R^2=0.590	R^2=0.652	R^2=0.663
	DW=0.41	DW=0.49	DW=0.491

Table 4.4 *Granger Non-Causality Tests (F-statistics)*

	1 October 1987 to 15 March 1989				23 March 1989 to 15 May 1991			
			Instantaneous				Instantaneous	
	δ◂e	e◂δ	δ◂e	e◂δ	δ◂e	e◂δ	δ◂e	e◂δ
δ(t,1)	2.69 *	3.89 **	2.16	3.11 *	2.48 *	3.22 *	4.76 **	5.43 **
δ(t,3)	2.17	5.69 **	1.73	4.50 **	2.61 *	3.84 **	3.45 **	4.48 **
δ(t,12)	0.79	4.53 **	1.17	4.24 **	0.94	2.97 **	1.62	4.30 **
	N=75	df=4,62	N=75	df=5,61	N=112	df=4,99	N=112	df =5,98

Both the causality from the interest rate differential to the exchange rate as well as the simultaneity may stem from intramarginal interventions, which should, in principle, affect both the interest rate differential and the exchange rate. Therefore, we estimated a simple vector-autoregressive model for 1-month and 3-month terms in order to test the exogeneity of the total interventions of the central bank affecting liquidity in relation to the exchange rate and the interest rate differential. The null hypothesis is that the liquidity variable does not enter the model, which is tested with the help of the Chi-Square statistics.

The test statistics are presented in the *Table 4.5* for the two subperiods. In the first subperiod the test cannot reject the null hypothesis at the 5 per cent significance level for any of the maturities examined, whereas in the post-revaluation period interventions affecting liquidity seem to be highly significant. The results of the vector-autoregressive model also pointed to the exogeneity of the interest rate differential, thus supporting the view that the causality runs from the interest rate differential to the exchange rate.

Table 4.5 *Vector-Autoregressive Model (Chi-Square Test)*

	1 Oct 1987 15 Mar 1989	23 Mar 1989 15 May 1991
1 month	6.101	32.738***
3 months	7.261	30.593***

4.4 Devaluation Risk

In the following we use the method suggested by Bertola and Svensson (1991) in order to obtain estimates for expected depreciation inside the band as well as for the devaluation risk in Finland in 1987–1991 (cf. Section 3.4).

Computation of the devaluation risk would be straightforward on the basis of eq. (3.10), if the expected future exchange rate inside the band were directly observable. This not being the case, we have to use indirectly constructed proxies for this variable. We started by estimating the following autoregressive equation:

$$e(t+\tau) = \alpha + \beta e(t) + n(t), \tag{4.2}$$

and used the estimated coefficients for α and β to obtain a proxy for the expected rate of depreciation inside the band. With this proxy and the observable data on the interest rate differential, calculation of the devaluation risk is straightforward. The residual $n(t)$ is assumed to be stationary with zero mean, although it need not necessarily be white noise.

In the following we use equation (4.2) as a benchmark. Moreover, we extend our analysis in three directions. First, we allow for the possibility that the previous intervention points may have had an effect on expected depreciation inside the band. Second, we examine the possibility that the total interventions by the central bank affect the future expected exchange rate. Finally, we want to shed some light on the usefulness of interest rate differentials in explaining the future expected exchange rate, as suggested in the previous section.

A few comments on eq. (4.2) are in order. If $0<\beta<1$, the equation has a mean-reversion property, the reversion point being $\alpha^*=\alpha/(1-\beta)$. This property may result from mean-reversion in the fundamental, which, in turn, may reflect systematic policy rules applied by the authorities. For instance, if the central bank aims at the mid-point of the band ($\alpha^*=\alpha=0$) and intervenes accordingly, though stochastically, the exchange rate and hence the expectation tend to move in that direction (*cf.* Lindberg and Söderlind, 1992).[13]

It is important that the reversion point is inside the band. Otherwise, eq. (4.2) could not be used to estimate the expected depreciation inside the band. If $\beta=1$, the equation would have a unit root. The exchange rate could, in princple, move beyond the band boundaries and hence the expectation could not be anchored to any reversion point. The equation is unstable, if $\beta>1$, in which case the expected depreciation could easily go beyond the band boundaries.

In order to take the signal effect of the central bank interventions into account, we estimate the following two variations of eq. (4.2):

$$(4.3) \qquad e(t+\tau) = \alpha + \gamma_1 e^p(t) + \gamma_2 e^s(t) + \beta e(t) + n(t), \text{ and}$$

$$(4.4) \qquad e(t+\tau) = \alpha + \gamma_3 e^a(t) + \beta e(t) + n(t),$$

where $e^p(t)$ and $e^s(t)$ are the previous buying and selling intervention points, respectively, and $e^a(t)$ is the average of the previous buing and selling intervention points, i.e. $e^a(t)=[e^p(t)+e^s(t)]/2$.

The signs of the intervention points are not entirely clear *a priori*. In principle, they should be positive. For instance, if the central bank raises the buying point e^p, it can be regarded as a signal that further appreciation is unwanted and hence unlikely. Similarly, if the selling point e^s is lowered, it may signal to the market that the central bank wants appreciation, rather than depreciation, in the near future. On the other hand, a negative sign is also possible. For example, if the exchange rate is allowed to rise for some while and the central bank then stops the depreciation by one or more sales, this may cause the exchange rate and expectations to move back in the appreciating direction. In eq.

[13] The basic target-zone model with interventions only at the edges of the band leads to a similar relationship for longer terms (Svensson, 1991b). Intramarginal interventions tend to linearize the relationship; see Lindberg and Söderlind (1992).

(4.3), the reaction to changes in intervention points may differ depending on the direction of the intervention. In eq. (4.4) it is assumed that the reaction to intervention points is symmetric irrespective of the direction of the intervention.

Because of the lack of independently observed data on expectations we have no means to test which equation and which information set has been most important for expectations. Although we cannot choose the preferred equation by statistical criteria, we interpret the intervention points as being important for exchange rate expectations if they appear to be statistically significant in forecasting the future exchange rate.

In addition to the intervention points (as proxies for the signal effects), we augmented eq. (4.2) by including total interventions $w(t)$. Total interventions cover all operations by the central bank which affect liquidity, *i.e.* both currency and money market interventions. To examine the possible effect of interventions on foreign exchange expectations we used a 5-day distributed lag on total interventions, $\lambda^* w(t)=\Sigma_i \lambda_i w_{t-i}$, i=0,...,5. We expect the coefficient of total interventions to be positive since central bank interventions increase the liquidity of the banking sector, which, in turn, tends to lower short-term interest rates.

Equations (4.2) to (4.4) were also augmented by including the distributed lag on the interest rate differential, $\lambda^* d(t)=\Sigma_i \lambda_i d_{t-i}$, i=0,...,4, to analyze the possible effect of the interest rate differential on the expectations of the future exchange rate within the band. We expect the coefficient to be negative, since within the band a higher interest rate differential should indicate expected appreciation of the exchange rate.

The estimated results for 1 and 3-month terms are presented in *Tables 4.6a-4.6b*. We used daily data for the period from 2 January 1987 to 15 May 1991.[14] The discontinuity caused by the March 1989 revaluation was removed from the data by dividing the sample into two subperiods at that point. In the first subperiod, a dummy was added to account for the widening of the band on 30 November 1988.

The results of the pre-revaluation period are presented in *Table 4.6a*. The estimated value of the rate of mean reversion in the benchmark equation (4.2), captured by the coefficient β, is in the range 0.7 to 0.8 . This coefficient declines to the range 0.2 to 0.5 when the intervention points are taken into account.[15] The parameter β decreases when the forecast horizon is lengthened, as expected.

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14 We also estimated the equation for 1-day and 5-day horizons. Interestingly, the results were very similar to the 1-month model as regards both the rate of mean reversion and the reversion point.

15 The t-values for the coefficients being less than unity are around -2 in eq. (4.4), while the critical level for the Dickey-Fuller test at the 5 per cent significance level is -2.87 for this sample size (Fuller, 1976, Table 8.5.2), for which reason the unit-root cannot be rejected. When intervention points are added (eqs. 4.5 and 4.6) β differs significantly from unity.

Table 4.6 a *Expected Exchange Rate Inside the Band*

Period: 2 January 1987 to 17 March 1989

e(t+22)

	1	2	3	4	5	6	7
Constant	-0.261 (-4.9)	-0.295 (-4.5)	-0.203 (-3.8)	-0.211 (-4.5)	0.144 (0.6)	0.386 (5.9)	0.323 (1.4)
e(t)	0.822 (11.0)	0.82 (10.9)	0.481 (2.9)	0.484 (3.2)	0.870 (12.7)	0.483 (3.6)	0.497 (3.7)
$e^P(t)$	-	-	0.202 (1.3)	-	-	0.289 (2.1)	-
$e^s(t)$	-	-	0.155 (1.0)	-	-	0.126 (0.9)	-
$e^a(t)$	-	-	-	0.358 (2.1)	-	-	0.411 (3.1)
d(t)	-	-	-	-	-0.177 **	-0.242 **	-0.228 **
w(t) x10^{-6}	-	172 **	-	-	-	-	-
Dummy	-0.201 (-0.8)	-0.22 (-0.8)	-0.366 (-1.4)	-0.370 (-1.4)	-0.174 (-0.9)	-0.324 (-1.9)	-0.341 (-1.9)
α^*	-1.45 -2.56D		-1.07 -1.77D	-0.87 -1.59D			
R^2	0.81	0.81	0.82	0.82	0.83	0.85	0.85
DW	0.14	0.13	0.12	0.12	0.20	0.16	0.16

e(t+66)

	1	2	3	4	5	6	7
Constant	-0.602 (-5.9)	-0.678 (-5.6)	-0.303 (-3.6)	-0.543 (-5.6)	-0.722 (-1.7)	-0.025 (-0.1)	-0.554 (-1.1)
e(t)	0.712 (3.5)	0.70 (3.6)	0.210 (1.7)	0.310 (1.2)	0.676 (2.9)	0.200 (1.6)	0.324 (1.2)
$e^P(t)$	-	-	0.900 (5.1)	-	-	0.931 (4.9)	-
$e^s(t)$	-	-	-0.496 (-2.1)	-	-	-0.497 (-2.3)	-
$e^a(t)$	-	-	-	0.426 (1.3)	-	-	0.390 (1.1)
d(t)	-	-	-	-	0.040 **	-0.122 **	-0.007 **
w(t) x10^{-6}	-	679 **	-	-		-	-
Dummy	-0.100 (-0.3)	-0.22 (-0.6)	-0.339 (-1.1)	-0.238 (-0.7)	-0.163 (-0.3)	-0.234 (-0.6)	-0.236 (-0.5)
α^*	-2.03 -2.44D		-1.25 -1.68D	-1.32 -1.66D			
R^2	0.53	0.55	0.69	0.56	0.55	0.70	0.57
DW	0.06	0.06	0.09	0.05	0.09	0.11	0.07

Table 4.6 b *Expected Exchange Rate Inside the Band*

Period: 20 March 1989 to 15 May 1991

e(t+22)

	1	2	3	4	5	6	7
Constant	-0.480 (-2.2)	-0.488 (-2.4)	-0.796 (-0.7)	-0.411 (-0.8)	-0.054 (-0.2)	0.521 (0.3)	0.867 (1.2)
e(t)	0.744 (7.5)	0.73 (7.8)	0.721 (6.9)	0.735 (5.9)	0.839 (8.3)	0.797 (8.0)	0.810 (7.8)
$e^p(t)$	-	-	-0.128 (-0.2)	-	-	0.070 (0.1)	-
$e^s(t)$	-	-	0.038 (0.3)	-	-	0.217 (1.3)	-
$e^a(t)$	-	-	-	0.042 (0.1)	-	-	0.404 (1.2)
d(t)	-	-	-		-0.069 **	-0.110 **	-0.110 **
w(t) x10^{-6}	-	-265 **	-	-	-	-	-
α^*	-1.87		-1.44	-1.87			
R^2	0.54	0.56	0.54	0.55	0.55	0.57	0.57
DW	0.15	0.16	0.14	0.15	0.17	0.17	0.17

e(t+66)

	1	2	3	4	5	6	7
Constant	-0.866 (-1.6)	-0.636 (-1.2)	-2.652 (-0.6)	-2.327 (-2.3)	0.231 (0.7)	-0.389 (-0.1)	-0.571 (-0.5)
e(t)	0.497 (2.2)	0.590 (2.9)	0.628 (3.7)	0.638 (3.1)	0.678 (4.2)	0.712 (4.1)	0.705 (3.8)
$e^p(t)$	-	-	-0.546 (-0.3)	-	-	-0.100 (-0.1)	-
$e^s(t)$	-	-	-0.404 (-2.5)	-	-	-0.176 (-0.7)	-
$e^a(t)$	-	-	-	-0.838 (-1.9)	-	-	-0.338 (-0.6)
d(t)	-	-	-	-	-0.219 **	-0.173 **	-0.173 **
w(t) x10^{-6}	-	-432 **	-	-	-	-	-
α^*	-1.72		-1.63	-1.63			
R^2	0.17	0.27	0.28	0.28	0.32	0.33	0.33
DW	0.07	0.08	0.08	0.08	0.10	0.10	0.10

Note: OLS-estimation. t-values based on Newey-West (1987) standard errors (lags equal to each maturity) in parentheses.
*** significant at 5 per cent level (F-test).*

The coefficient of total interventions affecting liquidity $w(t)$ obtains a positive sign and is significant (at 5 per cent a level using the F-test). The computed reversion point , $\alpha^{*}=\alpha/(1-\beta)$, is in the range -1 to -2 per cent (below the mid-point). Including the intervention points in eq. (4.3) shifts the reversion point upwards by around 0.5 percentage point. On the other hand, the widening of the band on 30 November 1988 lowers the reversion point by approximately the same amount as the strong edge was shifted downwards, although the coefficient is not significant.

The estimation results show that the signs of the intervention points are positive and of roughly equal size for both $e^{p}(t)$ and $e^{s}(t)$ over the 1-month forecasting horizon. The coefficients of the intervention points are, however, nonsignificant. It is interesting to note that the coefficient of the average intervention point $e^{a}(t)$ in equation (4.4) receives a significant coefficient. In other words, the estimation results suggest that intervention practices have been important for exchange rate expectations within the band in the sample and that the reaction to intervention points is symmetric irrespective of the direction of the intervention.

Unlike in the case of the 1-month horizon, the coefficients of intervention points for the 3-month horizon appear statistically significant. Moreover, the coefficient of the sell intervention point obtains a negative coefficient, whereas the coefficient of the average intervention point in equation 4.4 is nonsignificant. The estimated results of equations (4.2) to (4.4) modified to allow for the effect of the interest rate differential are also presented in *Table 4.6a* (equations 5-7). The coefficient for the interest rate differential is negative and significant in all cases for 1-month and 3-month horizons, as indicated by the previous discussion.

The results for the post-revaluation period are shown in *Table 4.6b*. The benchmark model (4.2) gives rather similar results as for the pre-revaluation period. The β-coefficient is 0.7 for the 1-month period and 0.5 for the 3-month period. Total interventions $w(t)$ now obtain a negative sign and are significant, which is in contrast to our hypothesis.

The intervention points, both the selling and buying points as well as the average intervention point, are insignificant for forecasting the future exchange rate over 1-month horizon. For the 3-month term both the selling and buying intervention points are negative, but only the selling point $e^{s}(t)$ seems to be significant. Hence, it appears that intervention practices have played a minor role in the latter period compared to the first subperiod. This can partly be explained by the fact that there were only a few changes in buying and selling intervention points during this period.

The computed reversion point, α^{*}, is around -1.8 per cent (below the mid-point) and declines somewhat when the intervention points are taken into account. It is between the average buy and sell intervention points and for most of the time is slightly above the actual exchange rate. However, the fact that in most cases the constant term is not significantly different from zero, implies that the reversion point, if any, may have been at around the middle of the band in the latter estimation period.

Finally, when modifying the equations to allow for the effect of the interest rate differential on the expected future exchange rate, the coefficient of the interest rate differential is again significant and negative as expected.

All in all, the results of estimation regarding intervention points are mixed and difficult to interpret. Nonetheless, *figure 4.3* and empirical evidence from the pre-revalution period support the argument that intervention practicies within the band have been important in determining the expected future exchange rate. Estimation results also suggest that the interest rate differential has been an important factor in determining the expected future exchange rate within the band.

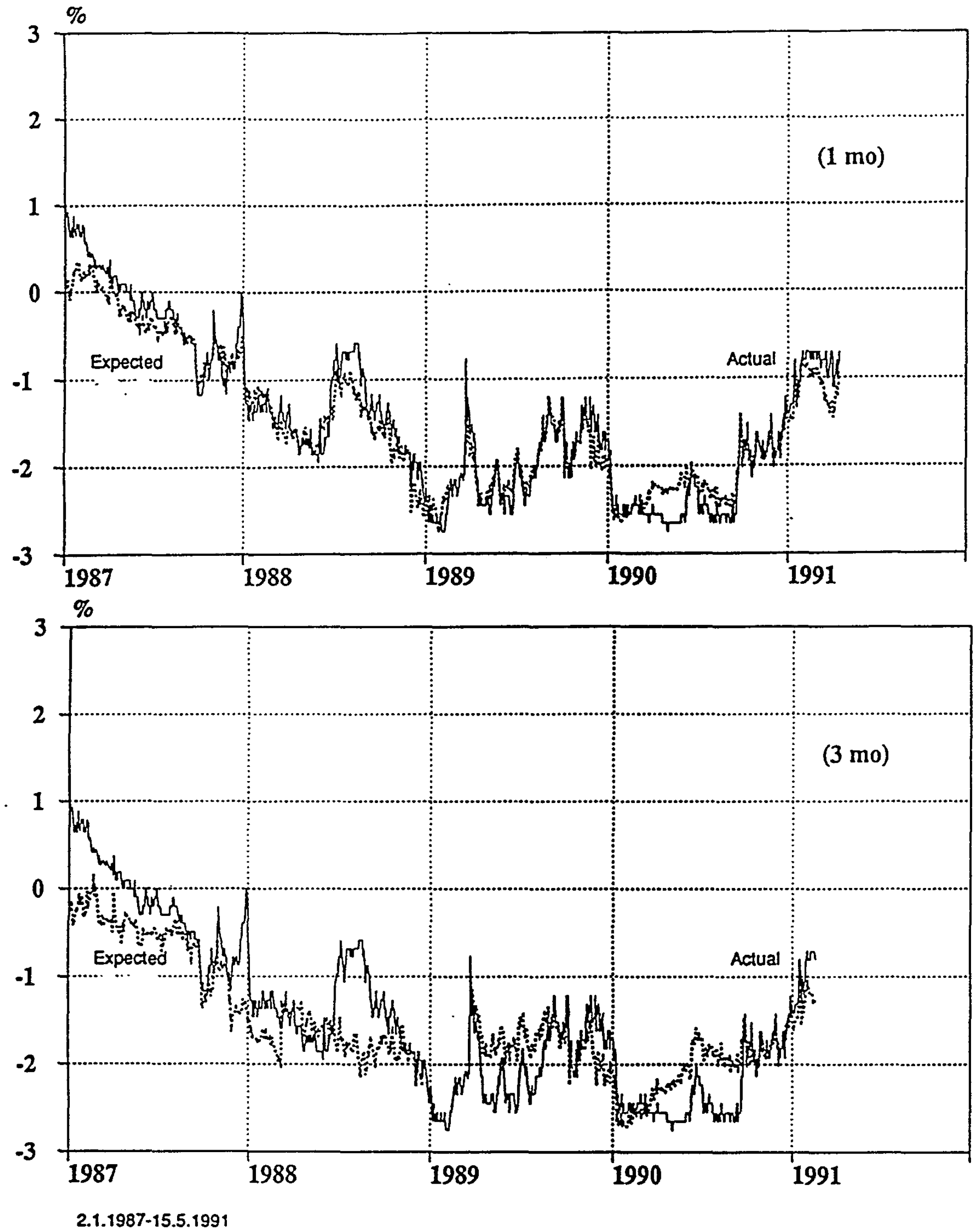
Hence, we decided to use eq. (4.3) augmented by the interest rate differential to calculate the expected future exchange rate and thereby the expected rate of depreciation inside the band. The expected future exchange rate is depicted in *Figure 4.4*, together with the actual exchange rate.

In the first three quarters of 1987, the expected exchange rate was below the actual exchange rate for both the 1-month and 3-month horizons. The implied contribution to the forward premium narrowed from 25 to 10 basis points for the 1-month term, implying that the annualized expected rate of appreciation inside the band declined from around 3 to 1 per cent. For the 3-month term, the implied forward premium (for domestic currency) narrowed from 75 to 20 basis points, giving approximately the same annualized expected appreciation. Since interventions were predominantly purchases and since the buy intervention point (with a positive coefficient) was successively lowered, this implies that interventions slowed the speed of the ongoing appreciation.

The expected future exchange rate remained mostly below the current spot rate in late 1987 and early 1988 for the 3-month term. For the 1-month term it exceeded the current spot rate in the first quarter of 1988. The depreciation of the currency in late summer 1988, which was halted by sell interventions, did not raise the expected future exchange rate by an equal amount. The annualized forward premium (for domestic currency) rose to the 4 to 5 per cent range. The interest rate differential should have declined, but it in fact it did not. Since the March 1989 revaluation, the expected future exchange rate has generally exceeded the current spot rate, implying expected depreciation inside the band. The computed annualized forward discount varied between 1 and 2 per cent. Exceptions are the last quarter of 1989 and the first quarter of 1991, when the expected rate was slightly below the current spot rate.

The inclusion of intervention points stabilizes the expected future exchange rate somewhat in comparison with the expected future exchange rate calculated on

Figure 4.4 *Expected Future Exchange Rate and the Actual Rate*



the band declined from around 3 to 1 per cent. For the 3-month term, the implied forward premium (for domestic currency) narrowed from 75 to 20 basis points, giving approximately the same annualized expected appreciation. Since interventions were predominantly purchases and since the buy intervention point (with a positive coefficient) was successively lowered, this implies that interventions slowed the speed of the ongoing appreciation.

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The inclusion of intervention points stabilizes the expected future exchange rate somewhat in comparison with the expected future exchange rate calculated on the basis of eq. (4.2) and also in comparison with the current spot rate. The implication is that, if the intervention points have an affect on expectations in the manner described above, interest rate volatility should increase.

In accordance with equation (3.10), we calculated the devaluation risk by subtracting from each observed interest rate differential the corresponding estimate of the expected rate of depreciation within the band. That is, the devaluation risk is equal to

$$(4.5) \quad g(t) = \delta_\tau(t) - [\alpha + (\beta-1)e(t) + \gamma_1 e^p(t) + \gamma_2 e^s(t) + \gamma_3 \lambda^* d(t)]/\tau,$$

where $\delta_\tau(t)$ is the interest rate differential (annualized simple rates) for term τ (in years) and where the estimated values are used for β, γ_1, γ_2 and γ_3. The devaluation risk g(t) is the product of the expected size of a devaluation and the probability intensity of devaluation.

The calculated devaluation risk for the 1-month and 3-month terms is shown in *Figure 4.5*. The devaluation risk is highly volatile and the volatility increases towards the end of the period.[16] It is correlated with the interest rate differential, but it is not identical with it. First, the interest rate differential is always positive, while the devaluation risk occasionally becomes zero or even negative. Secondly, it is more volatile than is the interest rate differential, and the volatility is higher for the 1-month than for the 3-month term. It is notable that zero or negative values appear in summer 1989 as well as in summer 1990, when the interest rate differential fell below 2 per cent. The high volatility of the devaluation risk in 1988 is, in part, due to interventions or, more accurately, to the manner in which the expected future exchange rate was estimated. As noted above, the volatility of the interest rate differential should have increased in 1988, because the discrepancies between the expected future exchange rate and the current spot rate were comparatively large in that year. This did not happen,

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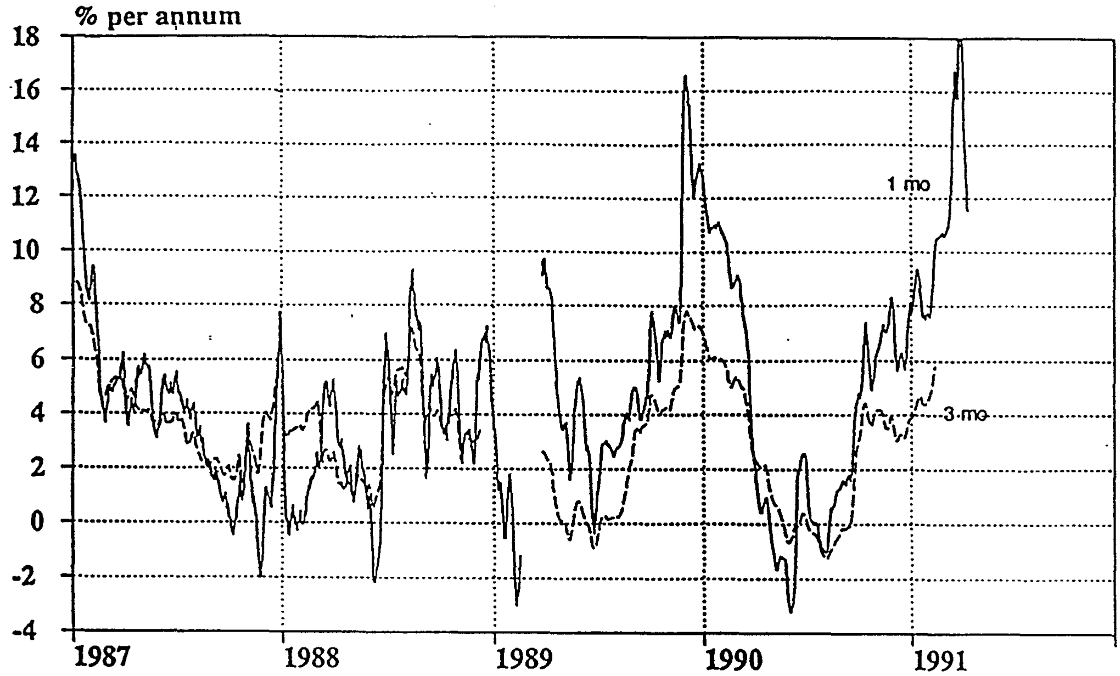
16 The EMS-currency bands have gained increased credibility between 1987 and 1991 (see Frankel and Phillips, 1991; Rose and Svensson, 1991; Svensson, 1991a; and Weber, 1991). In Finland, as too in Sweden, credibility problems have increased during the same period (*cf.* Lindberg, Svensson and Söderlind, 1991).

Figure 4.5 *Perceived Devaluation Risk*



2.1.1987-15.5.1991, 5 days moving average

which may indicate the possibility that the central bank attempted to depress the exchange rate in order to raise the interest rate differential.

The rapid resurgence of confidence at the very beginning of 1987 after the unrest in 1986 is reflected in the data, although the devaluation risk of 4 per cent in the middle of 1987 appears high in the light of other evidence. The steep step-by-step increase in the devaluation risk and in the interest rate differential, in autumn 1989 was connected with news concerning the budget and the trade balance, as well as with uncertainty surrounding wage negotiations. The sharp downward movement in summer 1990 is somewhat surprising given the fact that the sharp deterioration of the economic situation was more widely acknowledged than before. The profile in the devaluation risk in autumn 1990 is very similar to that of the previous autumn, except that the perceived risk continued to rise owing to the uncertainty surrounding the forthcoming general election.

From the end of 1987 to summer 1989, the devaluation risk for the 3-month term varied around 2–3 per cent. In autumn 1989 and again in winter 1991, it rose to around 6 per cent. Recall that the perceived devaluation risk is the product of the expected size of a devaluation and the probability intensity of a devaluation. A risk of 2 per cent is hence consistent with a 10 per cent devaluation with a probability of 20 per cent per annum. This corresponds to a 2 ½ per cent probability per a 3-month period. The same devaluation risk is, however, equally consistent with a 4 per cent jump in the exchange rate at the probability of 50 per cent per annum, that is 12 ½ per cent per a 3-month period. In the latter case, the exchange rate could jump inside the official band, although the 'unofficial band' maintained by sell interventions in the lower half of the official band has not been credible. Part of the perceived devaluation risk calculated by our method may therefore reflect uncertainty concerning at what point the upward movement in the exchange rate would be stopped, that is the targeted exchange rate. Similarly, those cases (in autumn 1989 and winter 1991) where the perceived devaluation risk for the 3-month term rose to 6 per cent are consistent with an expected 15 per cent devaluation with a probability of 10 per cent per 3-month period (40 per cent per annum).

5 CONCLUSIONS

This paper has examined developments in the Finnish money and foreign exchange markets in the light of the recent literature on target-zone models and discussed the Finnish experience of maintaining the exchange rate within the currency band. Although the empirical evidence of the target-zone models examined by several authors is relatively mixed, the target-zone models provide useful tools in analyzing developments in the money and foreign exchange markets.

When the basket peg and the currency band regime were formally adopted in Finland in 1977, the financial markets and capital movements were strictly regulated. This provided considerable room for manoeuvre in monetary policy. Although the formal deregulation took place as late as in the latter half of the 1980s, the effectiveness of capital controls and interest rate regulations had already started to erode in the early part of the decade. Since 1983, each successive Government has announced a stable currency as a cornerstone of its economic policy. Despite this, the pressure against the currency has gathered momentum each time the economy has slowed.

The period since 1986 is in many respects an extraordinary phase in Finnish economic history. The year 1986 itself witnessed what, at the time, was the most powerful speculative attack over against the currency. This was repelled by prompt central bank action on the interest rate front, although uncertainty subsided only after it was clear that the economy had embarked on a strong cyclical upswing. The driving forces behind the boom, were constantly improving terms of trade and a boom in consumption and construction. In textbook terminology, the IS-curve shifted to the right. As these fundamentals were not counteracted by tighter fiscal policy, the pressure was towards real appreciation of the currency. Given the counter-inflationary stance of monetary policy (LM-curve unchanged or shifted to the left), there was a pressure on interest rates which led to currency appreciation until the markka strengthened to the strong edge of the band and was ultimately revalued in March 1989.

The boom culminated in the most severe peacetime recession ever experienced in Finland. The pressure against the currency once again gathered momentum. The November 1991 devaluation was a blow to credibility and the currency has had to face repeated attacks since then.

Against this background the Finnish data provide a good opportunity to examine some of the implications of the target-zone models. In the empirical part of the present paper the relationship between the interest rate differential and the exchange rate was examined. The question of causality between the exchange rate and the interest rate differential was also raised and the possible effect of central bank interventions were taken into account in estimating the future exchange rate within the band. This proxy for the expected exchange rate was then used to calculate the devaluation risk of the Finnish markka.

The findings of the paper support the argument that for a given period the Finnish data exhibit some of the properties of the basic target-zone model. However, our findings support the view that causality runs from the interest rate differential to the exchange rate and not from the exchange rate to the interest rate differential, as implied by the basic target-zone model. The estimation results also indicate that intervention practices have been an important factor in determining the expected future exchange rate.

In retrospect, it would appear that the band arrangement has provided some room for monetary policy autonomy, although any quantitative assessment of its significance is most uncertain. In the post-1986 period up to autumn 1989, the average interest rate differential of around 2 percentage points helped to maintain the tendency for capital inflows, whereas capital outflows resulted when the interest rate differential fell to 1 percentage point or below. It therefore appears that an interest rate differential of between 1 and 1.5 percent points would have kept currency flows in balance on average during the period concerned. In terms of the interest rate differential, the degree of monetary policy autonomy was about 50 basis points at most, which was not much and certainly not sufficient to prevent serious overheatening of the economy.

With the benefit of hindsight, the 1991 devaluation was caused by a gradual deterioration in confidence in the economic policies pursued. The fixed exchange rate test, which in Finland coincided with the deepest recession in the post-war era, proved to be extremely difficult.

Monetary policy, which aimed at a stable exchange rate and low inflation, was not supported by sufficient flexibility in fiscal policy. As a result, the policies aimed at improving the economy through structual adjustment and increasing competitiveness *via* nominal price and cost adjustments lacked credibility. The task of making economic policy was also complicated by the disagreement on policy options within political circles and by the fact that many of the necessary cuts in public expenditure needed support from the opposition. The lack of credible policy alternatives eventually resulted in the devaluation of the markka.

6 POSTSCRIPT

After this paper was written the Finnish money and foreign exchange markets experienced severe turbulence. The nervousness in the currency markets was partly due to the harsh adjustment process the Finnish economy is going through and the difficulties in drawing up a politically acceptable economic programme to tackle the serious economic problems. In addition, increasing nervousness in the European foreign exchange markets contributed to instability in the domestic foreign exchange markets and fuelled demands for a second devaluation of the markka within a year.

Doubts about the commitment to a stable exchange rate, together with the fact that the Government was unable to impress the markets despite a relatively restrictive budget for 1993, contributed to a substantial capital outflow in the course of August and early September 1992. Since the economic conditions for maintaining a stable exchange rate did not exist the Board of Management of the Bank of Finland allowed the markka to float on 8 September, 1992. The Bank announced that the fixed exchange rate regime (fixed band) would be restored as soon as the economic situation permitted and the appropriate policies were in place.

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