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Estimating Exchange Market Pressure and the Degree of Exchange Market Intervention for Finland during the Floating Exchange Rate Regime

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Abstract

In this paper, we use a fairly simple monetary macro model to calculate the quarterly measures of exchange market pressure and the degree of the Bank of Finland's intervention during the time the markka was floated. Exchange market pressure measures the size of the exchange rate change that would have occurred if the central bank had unexpectedly refrained from intervening in the foreign exchange market. Intervention activity of the central bank is measured as the proportion of exchange market pressure relieved by foreign exchange interventions.

According to the measures, exchange market pressure decreased during the course of the markka float. Looking at the float as a whole, we cannot say whether depreciation or appreciation pressure was clearly dominant. However, the quarterly exchange market pressure was more often negative than positive.

The intervention indices indicate that the Bank of Finland limited the quarter-by-quarter changes in the external value of markka almost totally allowing markka to drift slowly towards its underlying free-float equilibrium value. The estimates of intervention activity during periods of appreciation and depreciation pressure diverged most in 1994 and 1996. In 1994, depreciation pressure was dampened more carefully than appreciation pressure. In 1996, on the other hand, the Bank of Finland reacted much more cautiously to appreciation pressure. Overall, the Bank of Finland's reactions to appreciation pressure seem to have varied markedly, while its reactions to depreciation pressure seem to have been more consistent.

Keywords: exchange market pressure, exchange market intervention, floating exchange rate regime

Tiivistelmä

Tutkimuksessa lasketaan yksikertaista monetaarista makromallia apuna käyttäen valuuttamarkkinoiden paine ja Suomen Pankin valuuttainterventioaktiivisuus neljännesvuosittain kellutuksen aikana. Valuuttamarkkinoiden painetta mitataan valuuttakurssin muutoksena, joka olisi toteutunut, jos keskuspankki olisi odotusten vastaisesti pidättäytynyt intervenoimasta valuuttamarkkinoilla. Keskuspankin interventioaktiivisuutta mitataan keskuspankin valuuttainterventioillaan imemän paineen osuutena valuuttamarkkinoiden kokonaispaineesta.

Paine-estimaatit osoittavat, että paine markan ulkoista arvoa vastaan pieneni kellutuksen aikana. Kun keskimääräisiä heikentymis- ja vahvistumispaineita verrataan toisiinsa, nähdään, ettei kumpikaan ollut selvästi hallitseva. Valuuttamarkkinoiden paine oli kuitenkin useammin markkaa vahvistava kuin markkaa heikentävä.

Interventioindeksien mukaan Suomen Pankki tasoitti markan ulkoisen arvon vuosineljännesten välisen vaihtelun lähes kokonaan siten, että se antoi markan lähestyä hitaasti puhtaan kellunnan oloissa määräytyvää tasapainoarvoa. Heikentymis- ja vahvistumisperiodien interventioindeksit eroavat toisistaan eniten vuosina 1994 ja 1996. Vuonna 1994 Suomen Pankki hillitsi heikentymispaineita enemmän kuin vahvistumispaineita. Sen sijaan vuonna 1996 Suomen Pankki reagoi herkemmin vahvistumispaineisiin. Kaiken kaikkiaan Suomen Pankin suhtautuminen vahvistumispaineisiin näyttää vaihdelleen selvästi. Heikentymispaineisiin se näyttää reagoineen johdonmukaisemmin.

Asiasanat: valuuttamarkkinoiden paine, valuuttainterventiot, kelluvan kurssin järjestelmä

Contents

1 Introduction

The Finnish markka floated from 8 September 1992 to 11 October 1996. During these four years, the Bank of Finland publicly maintained that it purchased and sold foreign currency in the foreign exchange market and influenced the exchange rate of markka only to smooth large day-to-day or intra-day fluctuations. It is obvious, however, that foreign exchange market pressure against the markka affected the intervention activity of the Bank of Finland. It also seems that this pressure varied considerably during the floating period.[1] In this paper, therefore, we attempt to measure the pressure against markka and find out how the Bank of Finland reacted to such pressure ie how clean or dirty the float was and whether the Bank's reactions were symmetric or asymmetric. We use the method presented by Weymark (1995) in which a fairly simple monetary macro model is used to calculate the quarterly measures of exchange market pressure and the degree of central bank intervention. Actual daily intervention data is used to calculate the quarterly aggregated pressure and intervention activity measures.

The paper is organized as follows. Sections 2, 3 and 4 summarize the analytical model, the measure of exchange market pressure and the measure of the degree of intervention based on Weymark (1995). Quarterly measures of exchange market pressure and intervention activity are calculated using Finnish data in section 5. In section 6, the estimated values of exchange market pressure and the degree of intervention are used to analyse the intervention policy of the Bank of Finland over the floating period. A brief summary and conclusion is found in section 7.

2 The model

The model assumes a small open economy with rational expectations. The domestic price level is influenced by the level of foreign prices and the exchange rate, though purchasing power parity does not necessarily hold. Domestic output and foreign price levels are exogenous. Financial markets are assumed to be well-developed and domestic and foreign assets are perfect substitutes. Domestic residents hold domestic currency for transactions and foreign claims for speculation. Foreign and domestic interest rates are linked through an uncovered interest rate parity. The central bank reacts to changes in the exchange rate by purchasing or selling foreign exchange reserves.

$$m_t^d = p_t + b_1 y_t - b_2 i_t + v_t \tag{1}$$

$$p_t = a_0 + a_1 p_t^* + a_2 e_t \tag{2}$$

[1] See Pösö and Spolander (1996).

$$m_t^s = m_{t-1}^s + \Delta d_t + \Delta r_t \tag{3}$$

$$i_t = i_t^* + E[e_{t+1}|t] - e_t \tag{4}$$

$$\Delta r_t = -\rho_t \Delta e_t \tag{5}$$

in which

$$\Delta d_t = \frac{(h_t D_t - h_{t-1} D_{t-1})}{M_{t-1}} \tag{6}$$

$$\Delta r_t = \frac{(h_t R_t^e - h_{t-1} R_{t-1})}{M_{t-1}} = \frac{(\Delta h_t R_{t-1} + h_t I_t)}{M_{t-1}} \tag{7}$$

$$R_t^e = R_{t-1} + I_t \tag{8}$$

m_t = the logarithm of money stock with s and d denoting supply and demand
p_t = the logarithm of domestic price level
y_t = the logarithm of real domestic output
i_t = the logarithm of domestic interest rate level
v_t = the stochastic money demand disturbance
e_t = the logarithm of exchange rate expressed as fim/dem
h_t = the money multiplier
D_t = the stock of domestic credit
M_{t-1} = the inherited money stock
R_{t-1} = the inherited stock of foreign exchange reserves
I_t = the foreign exchange interventions of the central bank
ρ_t = the central bank's time-variant response coefficient
a_2 = the exchange rate elasticity of the domestic price level
b_2 = the interest rate elasticity of the demand for money

An asterisk denotes the foreign counterparts of the relevant domestic variables. The notation $E[e_{t+1}|t]$ represents the expected value of the exchange rate in period t+1, conditional on the information available in period t. Private agents and the central bank have access to the same information and the exchange rate e_t and the domestic interest rate i_t are the only variables that domestic agents can observe contemporaneously. When Δe_t is positive (negative) domestic currency depreciates (appreciates) and when Δr_t is negative (positive) the central bank sells (purchases) foreign currency. The central bank reacts to markka appreciation (negative Δe_t) by purchasing foreign currency (positive Δr_t) and to markka depreciation (positive Δe_t) by selling foreign currency (negative Δr_t). The size of foreign exchange reserves is assumed to affect the central bank's intervention activity.

It should be noted that due to the definition of Δr_t, both foreign exchange interventions and changes in the money multiplier affect Δr_t, ie Δr_t may change even though there are no foreign exchange interventions. Thus, the model adopts the monetary channel of foreign exchange interventions assuming that the central bank can control the changes in the money multiplier.[2] The change in money multiplier either strengthens or dampens the effect of foreign exchange intervention on money market liquidity and exchange rate, and, hence, on the measure of exchange market pressure and the degree of central bank intervention. In the extreme case, the change in money multiplier may change the sign of the measure of exchange market pressure. If the money multiplier increases sufficiently, money market liquidity may increase and strengthen depreciation pressure on domestic currency even though the central bank has been selling foreign currency in order to reduce money market liquidity and dampen the depreciation pressure. This happens especially in connection with over-sterilized foreign exchange interventions.

Substituting equations reveals the demand for and supply of money in the economy:

$$\Delta m_t^d = a_1 \Delta p_t^* + (a_2 + b_2)\Delta e_t + b_1 \Delta y_t - b_2 \Delta i_t^* - b_2 \Delta E[e_{t+1}|t] + \Delta v_t \tag{9}$$

$$\Delta m_t^s = \Delta d_t - \rho_t \Delta e_t. \tag{10}$$

Under the assumption that the money market clears continuously, ie $m_t^s = m_t^d = m_t$ for all t, the change in exchange rate is given by:

$$\begin{aligned} \Delta e_t &= \frac{a_1 \Delta p_t^* + b_1 \Delta y_t - b_2 \Delta i_t^* - \Delta d_t + u_t - b_2 \Delta E[e_{t+1}|t]}{-(\rho_t + a_2 + b_2)} \\ &= \frac{X_t - b_2 \Delta E[e_{t+1}|t]}{-(\rho_t + a_2 + b_2)}. \end{aligned} \tag{11}$$

The numerator is the excess demand for money which is generated by the combination of exogenous disturbances X_t and by agent expectations of exchange rate changes $\Delta E[e_{t+1}|t]$ in period t. The possible sources of exogenous disturbances to the economy are changes in the foreign price level Δp_t^*, changes in the level of domestic output Δy_t, changes in the foreign interest rate level Δi_t^*, changes in domestic credit Δd_t and the random money demand shock $u_t = \Delta v_t$. It can be seen that the central bank's choice of ρ_t and the structural parameters a_2 and b_2 jointly determine the observed equilibrating exchange rate changes Δe_t.

One of the general characteristics of our simple monetary macro model is that the nominal exchange rate must be viewed as an asset price which depends on

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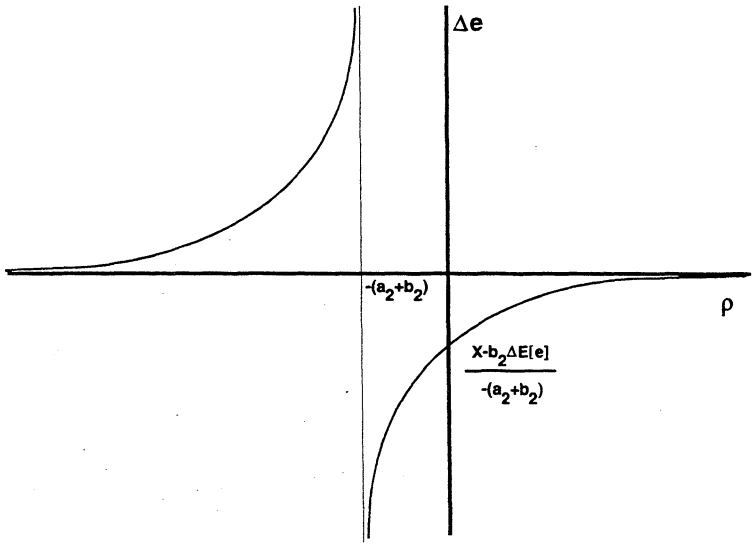
[2] In order to control the money multiplier, the central bank should be able to control both the money stock and the monetary base. The Bank of Finland has not used monetary aggregates as intermediate targets and, hence, has not tried to control the money multiplier.

expectations of future variables.[3] However, in Weymark (1995) the change in exchange rate expectations $\Delta E[e_{t+1}|t]$ is held constant so that the foreign exchange intervention does not alter the underlying size of the excess demand for money. A more conventional way would have been to form and solve a first-order stochastic difference equation explaining exchange rate dynamics in terms of exogenous disturbances X_t.

The relationship between observed equilibrating exchange rate changes Δe_t and the central bank's choice of response coefficient ρ_t is illustrated in Chart 1. When $\rho_t = \infty$, the central bank uses direct foreign exchange intervention to hold the exchange rate fixed. When $\rho_t = 0$, the central bank allows the exchange rate to float freely. There are no foreign exchange interventions and no changes in the domestic money supply. Any existing excess demand for domestic currency is eliminated by private market forces. Values $0 < \rho_t < \infty$ characterize intermediate intervention policies where the central bank dampens appreciation and depreciation pressure by purchasing and selling foreign currency. When $-(a_2+b_2) < \rho_t < 0$, the central bank magnifies the exchange rate changes; when $\rho_t < -(a_2+b_2)$, it aggressively reverses the exchange rate movement.

Chart 1.



3 Exchange market pressure

Exchange market pressure is the magnitude of money market disequilibrium that is removed either through exchange rate changes or through central bank's foreign exchange interventions. It measures the total excess demand for a currency as the exchange rate change which would have been required in order to remove this excess demand in the absence of exchange market intervention, given the expectations are generated by the exchange rate policy actually implemented. In

[3] See eg Obstfeld and Rogoff (1996).

other words, the exchange market pressure measures the size of the exchange rate change that would have occurred if the central bank had unexpectedly refrained from intervening in the foreign exchange market. The expectations associated with free float will differ from those held under the policy actually implemented. For this reason, the imputed exchange market pressure calculations should not generally be interpreted as the exchange rate change that would have occurred under a free floating exchange rate system. Rather, the exchange market pressure is best viewed as a measure of the size of external imbalance.

Exchange market pressure could, of course, be observed directly if the domestic currency was allowed to float freely. Since this is not the case, the magnitude of exchange market pressure has to be imputed from observed changes in the exchange rate Δe_t and foreign exchange reserves Δr_t. The observed changes in foreign exchange reserves are converted into exchange rate equivalent units and combined with observed changes in exchange rate to yield a composite summary statistic. When all intervention takes the form of purchases or sales of foreign exchange reserves, the exchange market pressure formula[4] is

$$EMP_t = \Delta e_t + \left(\frac{-\partial \Delta e_t}{\partial \Delta r_t} \right) \Delta r_t. \tag{12}$$

With $\Delta r_t = -\rho_t \Delta e_t$, the exchange market pressure formula consistent with the model employed can be obtained from

$$\Delta e_t = \frac{X_t - b_2 \Delta E[e_{t+1}|t]}{-(\rho_t + a_2 + b_2)} \tag{13}$$

that is

$$\Delta e_t = \frac{-(X_t - b_2 \Delta E[e_{t+1}|t] - \Delta r_t)}{a_2 + b_2} \tag{14}$$

and further

$$\frac{d\Delta e_t}{d\Delta r_t} = \frac{\partial \Delta e_t}{\partial X_t} \cdot \frac{dX_t}{d\Delta r_t} + \frac{\partial \Delta e_t}{\partial \Delta E[e_{t+1}|t]} \cdot \frac{d\Delta E[e_{t+1}|t]}{d\Delta r_t} + \frac{\partial \Delta e_t}{\partial \Delta r_t} \cdot \frac{d\Delta r_t}{d\Delta r_t}. \tag{15}$$

The intervention elasticity of exchange rate $\partial \Delta e_t / \partial \Delta r_t$ converts observed foreign reserve changes into equivalent exchange rate units. The expected change $\Delta E[e_{t+1}|t]$ is held constant when EMP_t is imputed so that the conversion does not

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[4] When the foreign exchange intervention is not allowed to change money market liquidity ie when the foreign exchange intervention is sterilized the exchange market pressure formula has the general form $EMP_t = \Delta e_t + \eta(\Delta r_t - \Delta d_t)$ where Δd_t represents the sterilizing domestic credit change. When $\Delta d_t = \Delta r_t$ the foreign exchange intervention is fully sterilized and the exchange market pressure is determined solely by the observed change in the exchange rate.

alter the underlying size of the excess demand for money. Therefore, the intervention elasticity of exchange rate is

$$\frac{d\Delta e_t}{d\Delta r_t}=\frac{\partial \Delta e_t}{\partial \Delta r_t}=\frac{1}{a_2+b_2} \tag{16}$$

and the measure of exchange market pressure implied by the model presented above is

$$EMP_t=\Delta e_t+\left(\frac{-1}{a_2+b_2}\right)\Delta r_t. \tag{17}$$

Because the exchange rate is expressed as fim/dem, negative values of EMP_t mean appreciation and positive values mean depreciation pressure. When evaluating and interpreting the values of EMP_t, it should be remembered that the intervention elasticity of exchange rate varies with the model specification and, hence, the values of EMP_t will not generally be model independent.

4 Intervention index

Intervention activity of the central bank is measured as the proportion of exchange market pressure relieved by foreign exchange interventions. When all interventions are either purchases or sales of foreign exchange reserves, the intervention index is defined as

$$\omega_t=\frac{-\Delta r_t}{(a_2+b_2)EMP_t}=\frac{\Delta r_t}{\Delta r_t-\Delta e_t(a_2+b_2)}. \tag{18}$$

When the central bank holds the exchange rate fixed $\Delta e_t = 0$ and $\omega_t = 1$. When the central bank allows the exchange rate to float freely $\Delta r_t = 0$ and $\omega_t = 0$. Values $0 < \omega_t < 1$ characterize intermediate intervention policies. When $\omega_t < 0$, the central bank magnifies the exchange rate changes generated by private market forces. At the other extreme, when $\omega_t > 1$, the exchange rate is observed to move in the opposite direction of what would have occurred in the absence of central bank intervention.

5 Estimation of exchange market pressure and the intervention index

We now estimate exchange market pressure against markka and the intensity of the intervention activity of the Bank of Finland under the floating exchange rate regime.[5] To do this, we calculate the measures of exchange market pressure and the degree of central bank intervention as suggested above using quarterly data from 1992Q4 to 1996Q3.

Our analysis is limited to fim/dem exchange rate because the Deutsche mark is used as an intervention currency in the Bank of Finland's foreign exchange operations. The exchange rates are quarterly averages of daily exchange rates. Positive changes in the exchange rate mean the depreciation and negative changes the appreciation of markka.

The daily purchases and sales of foreign currency are netted quarterly. Positive foreign exchange interventions mean that the Bank of Finland dampens markka appreciation by purchasing foreign currency ie dem. Negative foreign exchange interventions mean that the Bank of Finland dampens markka depreciation by selling dem.

In contrast to Weymark (1995), the foreign exchange interventions of the Bank of Finland are not approximated by the changes in official foreign exchange reserves. During the markka float, the government borrowed very actively from international financial markets. When the government raises a foreign currency denominated loan, it sells the currency to the Bank of Finland and when the central government amortizes such a loan or pays interest, it purchases the currency from the Bank of Finland. As a result, the official foreign exchange reserves of the Bank of Finland are affected not only by foreign exchange interventions but also by the government's foreign debt management. Since foreign exchange operations ensuing from the foreign debt management are a part of the government's fiscal policy, they are not allowed to affect the supply of markka, interest and exchange rates. Here, foreign exchange interventions include only those foreign exchange operations where the Bank of Finland has sought to affect the markka exchange rate.[6]

It is, however, assumed that the size of official foreign exchange reserves affects the intervention activity of the central bank. As official foreign exchange reserves decrease the central bank normally starts to worry about their sufficiency. In the extreme case, the central bank starts to intervene simply to increase its official foreign exchange reserves. To take into account the official size of foreign exchange reserves and the actual foreign exchange interventions, the actual foreign exchange interventions I_t are added to the official foreign exchange reserves which

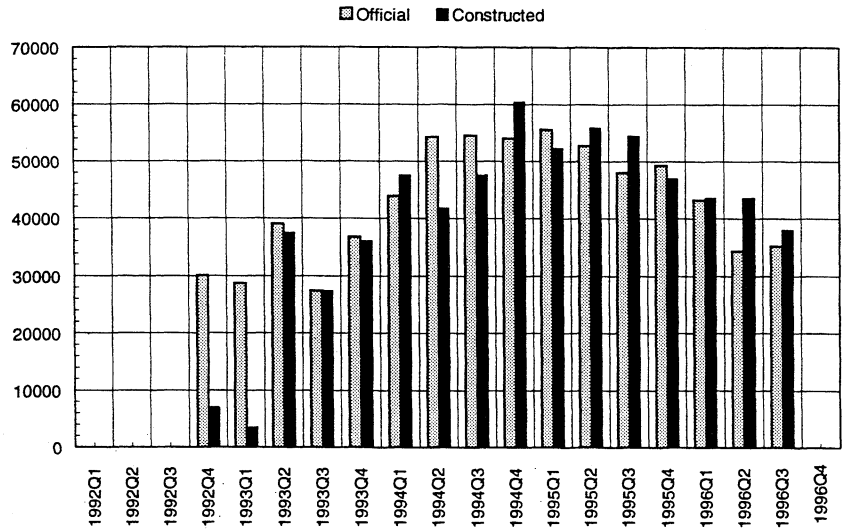
[5] To be precise, the intervention index is not totally in the Bank of Finland's control because the index is affected not only by foreign exchange interventions, but also by the changes in M1 and monetary base.

[6] Foreign exchange operations include both spot and forward operations.

existed in the end of previous period R_{t-1}.[7] As a result, the constructed foreign exchange reserves R^e_t differ from official foreign exchange reserves R_t by those foreign exchange operations which are caused by government's foreign debt management in period t.

Chart 2 shows both official (R_t) and constructed $(R^e)_t$ foreign exchange reserves. The biggest differences between these two measures occur in 1992Q4 and 1993Q1 when official reserves clearly exceeded constructed reserves. These differences resulted when heavy government borrowing from abroad was intensified by rapidly shrinking official foreign exchange reserves. During the currency crisis of 1992Q3, the Bank of Finland's defence of the markka included the use of foreign exchange forwards. When these forwards matured in 1992Q4 and 1993Q1, the official reserves would have decreased dramatically without foreign currency imports. The opposite situation prevailed in 1996Q2 and 1996Q3 when the government's foreign debt amortization decreased official foreign exchange reserves.

Chart 2. **Foreign exchange reserves (millions of FIM)**



Changes in foreign exchange reserves are determined with the constructed foreign exchange reserves R^e_t and the official foreign exchange reserves R_{t-1}. These are related to narrow money stock $M1_t$ which includes notes and coin in circulation and all deposits that can be immediately used as means of payment. The money multiplier h_t is obtained as the ratio of $M1_t$ to the monetary base B_t which includes notes and coin in circulation and the Bank of Finland's liabilities to financial institutions.[8] The money multiplier is allowed to vary over the sample period.

M1, the monetary base and the money multiplier are presented in Charts 3 and 4. The growth of M1 has been fairly stable during the markka float. However, it is

[7] The foreign exchange operations ensuing from the government's foreign debt management are included in R_{t-1}, but not in R^e_t.

[8] See Aaltonen and Aurikko and Kontulainen (1994) and the monthly Statistical Review of Financial Markets.

worth noting that the growth of M1 accelerated substantially after 1995Q3 due to maturing tax-exempt time deposits. Looking at the monetary base's graph, we can see one major change in 1993Q3. This change coincides with the change in the minimum reserve system. At the beginning of July 1993, cash reserve deposits were converted to required reserves, thereby decreasing the Bank of Finland's liabilities to financial institutions.

The required model-consistent estimates of exchange rate elasticity of domestic price level a_2 and the interest elasticity of the demand for money b_2 are obtained from Kuismanen (1995), Pösö (1995) and Ripatti (1994). The parameter estimates are the following:

$a_2 = 0.2883$[9]
$b_2 = 0.0926$.[10]

The quarterly estimates of exchange market pressure and the degree of foreign exchange intervention as well as the actual exchange rate changes, netted interventions in millions of markkas and the money multiplier are provided in Table 1. In the lower part of table, appreciation and depreciation pressure are separated and the corresponding intervention indices are compared. The estimates of exchange market pressure and intervention activity are also presented in Chart 5. The fim/dem exchange rate is presented in Chart 6.

[9] The exchange rate elasticity of import prices (0.6881) is obtained from Kuismanen (1995) and the import price elasticity of the domestic prices (0.4202) from Pösö (1995). The reported exchange rate elasticity of the domestic price level is the product of these two.

[10] The interest rate elasticity of the demand for money is calculated by using the interest rate semi-elasticity of M1 estimated by Ripatti (1994). The semi-elasticity of 1.5 is multiplied by 0.0617 which is the average three month HELIBOR-rate during the floating period 1992Q4-1996Q3.

Chart 3. **M1 and monetary base (millions of FIM)**

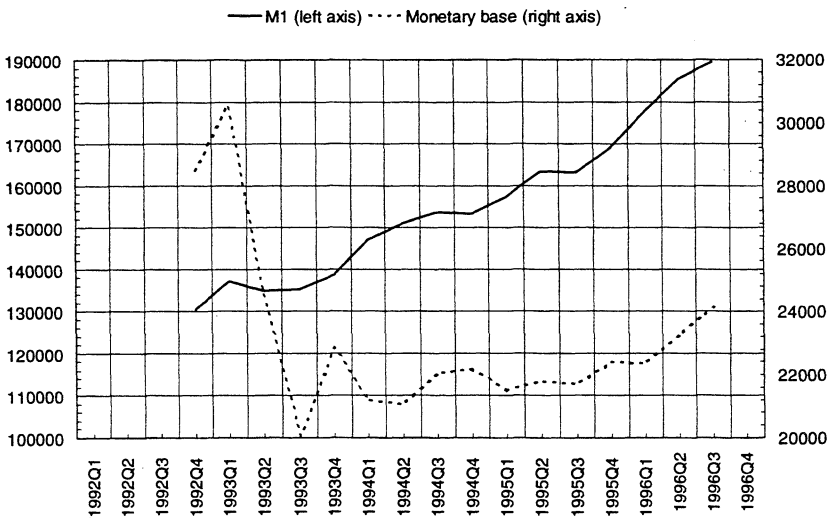


Chart 4. **Money multiplier**

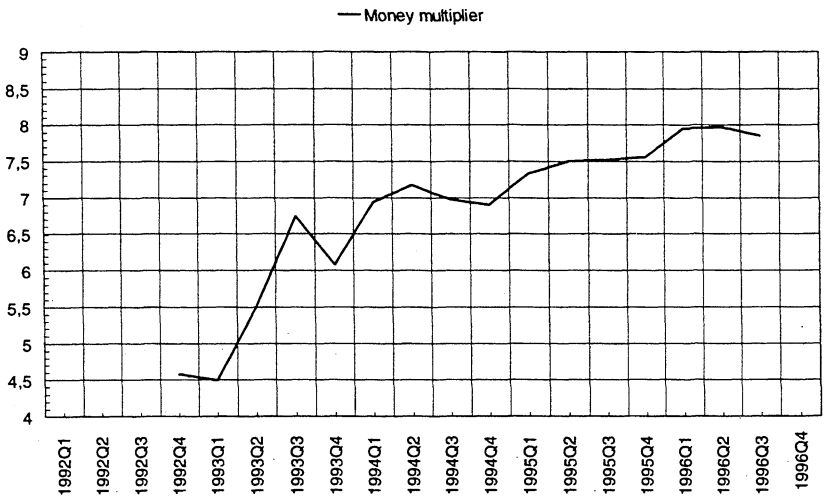


Chart 5. **Exchange market pressure and intervention index during Markka's floating 1992Q4-1996Q3**

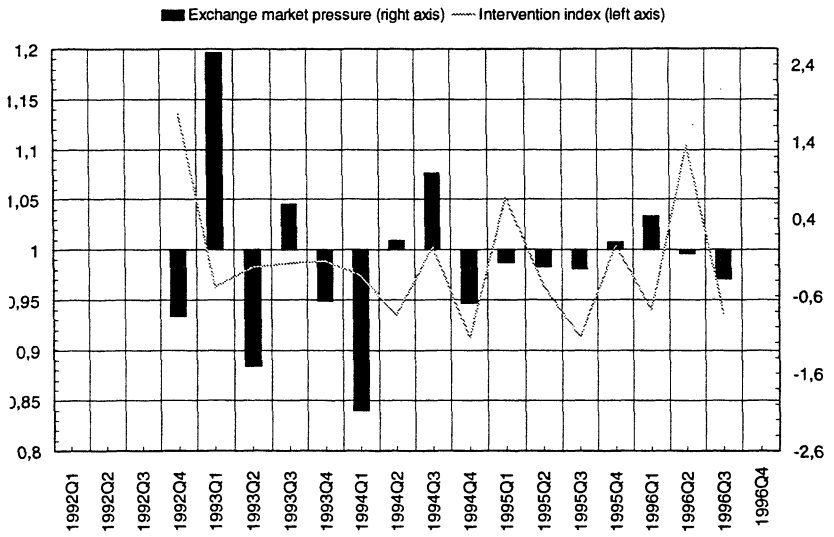


Chart 6. **FIM/DEM exchange rate**

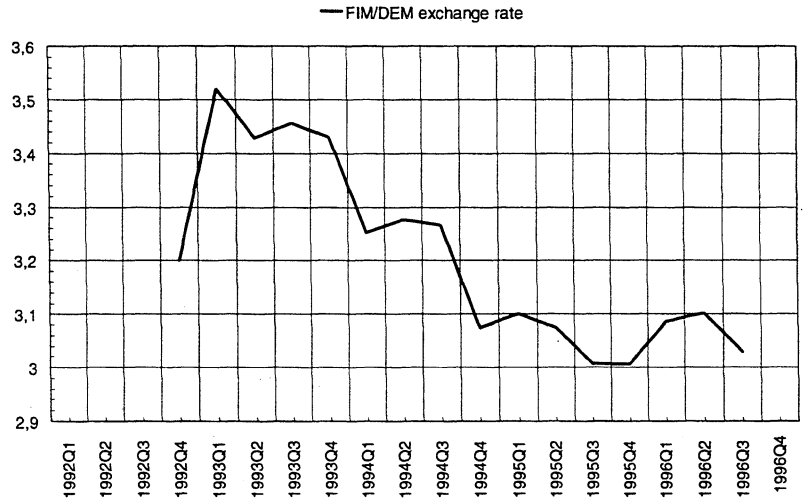


Table 1. **Intervention index and exchange market pressure 1992Q4-1996Q3**

Quarters	Intervention index	Exchange market pressure	Actual exchange rate change	Foreign exchange interventions	Money multiplier
1992Q4	1,14	-0,86	12 %	7030	4,6
1993Q1	0,96	2,55	10 %	-26610	4,5
1993Q2	0,98	-1,50	-3 %	8760	5,5
1993Q3	0,99	0,59	1 %	-11640	6,7
1993Q4	0,99	-0,67	-1 %	8610	6,1
1994Q1	0,97	-2,09	-5 %	10910	6,9
1994Q2	0,93	0,12	1 %	-2270	7,2
1994Q3	1,00	0,99	0 %	-6640	7,0
1994Q4	0,91	-0,69	-6 %	5910	6,9
1995Q1	1,05	-0,16	1 %	-1720	7,3
1995Q2	0,96	-0,22	-1 %	400	7,5
1995Q3	0,91	-0,25	-2 %	1730	7,5
1995Q4	1,00	0,09	0 %	-940	7,6
1996Q1	0,94	0,43	3 %	-5740	7,9
1996Q2	1,10	-0,05	1 %	340	8,0
1996Q3	0,94	-0,38	-2 %	3720	7,8
1992Q4-1996Q3	0,99	-2,11	6 %	-8150	6,8

	Appreciation pressure quarters		Depreciation pressure quarters	
	Average pressure	Average intervention	Average pressure	Average intervention
1992Q4	-0,86	1,14	-	-
1993Q1-Q4	-1,09	0,99	1,57	0,97
1994Q1-Q4	-1,39	0,94	0,55	0,97
1995Q1-Q4	-0,21	0,98	0,09	1,00
1996Q1-Q3	-0,21	1,02	0,43	0,94
1992Q4-1996Q3	-0,69	0,99	0,80	0,97
Quarters	10		6	
Total pressure	-6,88		4,77	

6 Bank of Finland intervention policy

After the Bank of Finland allowed the markka to float in September 1992, the pent up depreciation pressure burst forth causing a rapid devaluation of the markka. By October, however, the markka was confronting strong appreciation pressure which remained through November. As a result, the average pressure for the last quarter of 1992 was negative, which is indicated by negative exchange market pressure estimate in Table 1.

The intervention index for the last quarter of 1992 exceeds unity, indicating that despite strong appreciation pressure, the Bank of Finland purchased foreign currency and sold the markka so heavily that the markka depreciated. The most important reason for the large purchases of foreign currency in 1992Q4 was the maturing of forward contracts in a situation where the official foreign exchange reserves were already exceptionally small. These forward contracts were made just before the decision to float on 8 September 1992 in order to sterilize any large sales of foreign currency and postpone the effect of such sales on the markka supply and official foreign exchange reserves. Favourable exchange market conditions in 1992Q4 gave the Bank of Finland an opportunity to increase its foreign exchange reserves by purchasing currency directly from the markets without depreciating the value of markka significantly. The government also raised capital imports to increase official foreign exchange reserves. From 18 to 20 November 1992, the government imported FIM 13 billion worth of foreign currency from abroad.

Depreciation pressure that emerged in December 1992, prevailed through the first quarter of 1993. This depreciation pressure was partly due to a troubled Swedish economy and pressure on the Swedish krona. The Bank of Finland dampened the depreciation of the markka by selling FIM 26.6 billion worth of foreign currency and consequently, removed 96 % of the depreciation pressure. The markka depreciated 10 % in 1993Q1.

Positive news from Finland's export industries increased appreciation pressure in 1993Q2. As the pressure turned negative, the intervention index rose to 0.98. In other words, the Bank of Finland removed the pressure almost totally so that the markka appreciated only 3 % in 1993Q2.

In 1993Q3, speculation against ERM currencies, the widening of ERM fluctuation bands in early August, and depreciation pressure on the Swedish krona all influenced the value of the markka. The Bank of Finland dampened markka depreciation by selling FIM 11.6 billion worth of foreign currency. This eliminated the depreciation pressure almost totally, ie the intervention index was almost equal to unity so that the markka depreciated only 1 % in 1993Q3.

After a quarter of depreciation pressure, the markka confronted appreciation pressure in 1993Q4. This pressure further intensified in 1994Q and remained fairly strong as foreign investors increased their investment in Finnish government bonds and Finnish industry and investors sold foreign currency. The threat of a strike by bank employees in November 1993 caused appreciation of the markka as the export industry imported their export incomes faster than usual. The Bank of Finland removed 98 % of the pressure on average by purchasing FIM 19.5 billion worth of foreign currency during the last quarter of 1993 and the first quarter of 1994.

At the end of 1994Q1, US investment funds started to sell the markka and thereby caused depreciation pressure in 1994Q2. This depreciation pressure was moderate and the Bank of Finland eased its intervention activity and dampened only the few largest inter-day and intra-day changes. The exchange rate depreciated 1 % on average.

The Bank of Finland sold foreign currency and held the exchange rate fixed on average despite intense depreciation pressure on markka in 1994Q3. The Bank eased its intervention activity and let the markka appreciate in 1994Q4. In July and early August, the markka was fairly stable. The mid-August depreciation of the Swedish krona was reflected in the markka. The Bank of Finland reacted aggressively and neutralized the pressure. With the completion of successful budget talks and the increased likelihood of Finland's membership in the European Union, the markka appreciated in September and October. This appreciation seems to have been desirable because the Bank of Finland eased its intervention activity and let the markka rise.

The Mexican crises in the early 1995 had little impact on the external value of the markka. In March the Spanish peseta and Portuguese escudo were devalued in the ERM, but according to the exchange market pressure index, depreciation pressure on markka did not emerge. Instead, the foreign exchange pressure was negative in 1995Q1. This is somewhat strange because the Bank of Finland sold foreign currency worth of FIM 1,720 million as if it had tried to dampen depreciation pressure. According to the formula (7), foreign currency sales should make Δr_t negative and consequently, applying the formula (12), exchange market pressure should have been positive. In 1995Q1, however, an increase in the money multiplier h_t increased money market liquidity, depreciated the markka and cancelled out the negative liquidity effect of the Bank of Finland's intervention. As a result, Δr_t became positive as if the Bank of Finland had tried to dampen the markka's appreciation by raising money market liquidity. EMP_t became negative indicating appreciation pressure in 1995Q1. During this time, the markka actually depreciated and the intervention index exceeds unity as if the Bank of Finland had turned the appreciation pressure to depreciation.

The exchange market pressure was relative small in 1995Q2. The Bank of Finland's foreign exchange interventions were rare and the markka was allowed to float quite freely. The appreciation pressure intensified in early 1995Q3 as the government rating remained untouched, bond auctions succeeded well and foreign and Finnish investors started to buy markkas. The Bank of Finland broke the appreciation spiral by purchasing foreign currency in August. In September, there was restlessness in the international foreign exchange market as doubt concerning about Italy's ERM/EMU condition had been set of by the comments of German finance minister Theo Waigel. The markka started to depreciate, with the Bank of Finland attempting to dampen the largest intra-day movements. On average the Bank of Finland did not consider the appreciation pressure harmful in 1995Q2 and 1995Q3 and let the markka appreciate. It removed 96 % of the pressure in 1995Q2 and 91 % in 1995Q3.

Exchange market pressure turned slightly positive in 1995Q4. As quarterly averages of exchange rates conceal movements during each quarter, they are somewhat misleading in this case. Exchange market pressure in October was positive. It became negative in November, and then became clearly positive again in December. The Bank of Finland intervened only in December when it sold

foreign currency to dampen the depreciation of the markka. With these interventions the Bank of Finland managed to remove depreciation pressure, keeping the exchange rate fixed on average for 1995Q4.

Depreciation pressure intensified in 1996Q1 on rumours about the willingness of the Bank of Finland to depreciate the markka. By late January and early February, the pressure on the markka had reached its strongest point, and the Bank of Finland sold foreign currency to dampen the largest intra-day depreciations. This removed some 94 % of the pressure and the markka depreciated 3 % on average.

In 1996Q2 and 1996Q3 positive news about the Finnish economy and ERM speculation generated appreciation pressure on the markka. Appreciation pressure started to emerge in May after the Bank of Finland had supported the markka by selling foreign currency in April. During 1996Q2 the supply of markka increased so much that it not only neutralized the appreciation pressure, but in fact, depreciated the markka 1 %. The increase in the supply of markka was a result of foreign exchange interventions and an increase in the money multiplier.

ERM speculation increased considerably in 1996Q3. The Bank of Finland dampened the largest intra-day appreciations and attempted to stop appreciation by purchasing FIM 2.3 billion worth of foreign currency in late September. On average the Bank of Finland removed 94 % of the appreciation pressure and the markka appreciated 2 % in 1996Q3.

Looking at the float period as a whole, we cannot say that depreciation or appreciation pressure was clearly dominant. The average quarterly depreciation pressure was higher than average quarterly appreciation pressure, but there were 10 quarters of appreciation pressure against 6 quarters of depreciation pressure. When the sum of quarterly appreciation pressure is related to the sum of quarterly depreciation pressure, we end up with higher total appreciation pressure (-6.88) than total depreciation pressure (4.77).

Exchange market pressure decreased over time during the markka's float. In 1993, both appreciation and depreciation pressure were high and depreciation pressure was dominant. In 1994, the exchange market pressure turned negative and decreased considerably. It continued to fall in 1995. At the beginning of 1996, depreciation pressure increased momentarily. Later in 1996, ERM speculation caused the pressure to become increasingly negative.

The quarterly intervention indices vary between 0.91 and 1.14. Intervention indices varied very little in 1993, but the variation increased substantially after 1993. When the intervention index is interpreted, the choice of the monetary aggregate is important. In our case, the change in the foreign exchange reserves Δr_t is related to the narrow money stock $M1_t$. Therefore, the role of Δr_t in determining exchange market pressure EMP_t tends to increase and consequently, the intervention index ω_t tends to converge towards unity.

The average intervention index for the entire float period is 0.99. This indicates that the Bank of Finland limited quarter-by-quarter changes in the external value of markka almost totally, allowing the markka to drift slowly towards its underlying free-float equilibrium value. However, it should be remembered that when the sample period lengthens, the average exchange rate change converges to zero and consequently, the average intervention index converges to unity.

It can also be seen that the average intervention indices have been almost equal regardless of the direction of exchange market pressure. The average intervention index for appreciation pressure quarters slightly exceeds the corresponding index for depreciation pressure quarters suggesting that appreciation pressure was removed more completely than depreciation pressure (which is hardly surprising as appreciation pressure exceeded depreciation pressure during the markka float).

The estimates of intervention activity during periods of appreciation and depreciation pressure diverged most in 1994 and 1996. In 1994, depreciation pressure was dampened more carefully than appreciation pressure as markka appreciation was considered desirable. In 1996, on the other hand, it was desirable to let the markka fall, so the Bank of Finland reacted much more cautiously to appreciation pressure. Interestingly, the intervention index varied between 0.91 and 1.14 and the three highest and two lowest intervention indices occurred when exchange market pressure was negative. This means that the Bank of Finland's reaction to appreciation pressure varied during the float. When the exchange market pressure was positive, intervention index varied between 0.93 and 1.00 indicating that the Bank of Finland reacted to depreciation pressure more consistently during the markka's floating.

7 Conclusions

In this paper, we measured the pressure against the markka and attempted to ascertain how the Bank of Finland reacted to these pressure during the time the markka was floated. We used the method presented by Weymark (1995) in which a fairly simple monetary macro model is used to calculate the quarterly measures of exchange market pressure and the degree of central bank intervention. The model specification was originally chosen by Weymark with the Canadian economy in mind. As Finland is a small open economy, we believe that this particular model specification captures the most essential features of the Finnish economy. The actual daily intervention data was used to calculate the quarterly aggregated pressure and intervention activity measures.

Exchange market pressure measures the size of the exchange rate change that would have occurred if the central bank had unexpectedly refrained from intervening in the foreign exchange market. Intervention activity of the central bank is measured as the proportion of exchange market pressure relieved by foreign exchange interventions.

Exchange market pressure decreased during the course of the markka float. In 1993, both appreciation and depreciation pressure were high, with depreciation pressure being dominant. In 1994, the exchange market pressure turned negative and decreased considerably. It continued to fall in 1995. At the beginning of 1996, depreciation pressure again increased momentarily, but then turned increasingly negative as ERM speculation increased. Looking at the float as a whole, we cannot say whether depreciation or appreciation exchange market pressure was clearly dominant. However, the average exchange market pressure was more often negative than positive.

The quarterly intervention indices vary between 0.91 and 1.14. Intervention indices varied very little in 1993, but increased substantially after 1993. The average intervention index for the entire floating period is 0.99. This indicates that the Bank of Finland limited the quarter-by-quarter changes in the external value of markka almost totally allowing markka to drift slowly towards its underlying free-float equilibrium value. However, it should be remembered that when the sample period lengthens, the average exchange rate change converges to zero and consequently, the average intervention index converges to unity.

The Bank of Finland's reactions seem to have been somewhat asymmetric during the float. Its reactions to appreciation pressure varied markedly, while its reactions to depreciation pressure were more consistent.

Given the simplicity of the model, the estimates obtained must be viewed with caution. First, the exchange market pressure should be viewed as a measure of the size of external imbalance and not as required percentage change of the exchange rate. Second, as the change in foreign exchange reserves Δr_t is related to the narrow money stock $M1_t$, its role in determining the exchange market pressure EMP_t increases and, hence, the intervention index ω_t converges towards unity making the interpretations more discretionary. Third, quarterly averages smooth the changes in exchange rate and, hence, hide variation (perhaps too well). Fourth, when foreign exchange interventions are netted, any small net figures obtained do not necessarily mean low intervention activity. Finally, given the definition of Δr_t, both foreign exchange interventions and changes in the money multiplier affect Δr_t, ie Δr_t may change even in the absence of foreign exchange interventions. The effect of the central bank's money market interventions and the resulting interest rate changes on the exchange rate and, hence, their role as an exchange market pressure indicator should be considered and modelled explicitly.

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