'Large' vs. 'small' players: A closer look at the dynamics of speculative attacks[1]

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Abstract

Recent speculative attacks have directed attention to the role of "large players" — e.g. hedge funds and other highly leveraged institutions. We propose a simple model that allow the large player to move either before or after the small players. Previous models have suggested that large players may move before small players in order to induce them to attack as well. Anecdotal evidence suggests, however, that large players move in the rear to reap the interest rate benefit during the pre-crises period. We derive the conditions for when the large player choose to move early or late. In particular, the large player move late when the probability of a successful attack is high so that the benefit to inducing the small players to attack is small, and smaller than the gain by waiting. We address empirically the role of large and small players during three periods of speculative pressure on the Norwegian krone (NOK). Using data on net positions of "large" (foreigners) and "small" (locals), we find that large players moved last during the ERM-crises of 1992 and the pressure on Norwegian krone in 1997. Large players also moved last in the NOK-market during the Russian moratorium crisis of 1998. In this case we can also compare with the contemporaneous pressure on the Swedish krona (SEK). Interest rates did not increase in Sweden so there were little (risk adjusted) benefit to reap by a delayed attack. There are some evidence that large players moved early in the Swedish market.

JEL Classifications: F31, F41, G15

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1 Introduction

The problem of connecting currency crises to fundamentals has given room for a discussion of possible manipulation of exchange rates. It has become a ritual among many politicians to denounce hedge funds and other highly leveraged institutions, especially foreign, for manipulating exchange rates during speculative pressure. We analyze the decision of large and small players in a simple model, based on Corsetti, Dasgupta, Morris and Shin (2004), where the large player can choose to attack both before and after the small players. We then test the implications of the model using data on net positions of "large" (foreigners) and "small" (locals) players in Norway and Sweden.

Theory on currency crises have evolved in stages. In the first generation model of Krugman (1979) the collapse of the exchange rate is inevitable due to deteriorating fundamentals. Although this may explain many actual attacks, there are also a sufficient number of crises which are difficult to reconcile with fundamentals alone. In the second generation models, e.g. Obstfeld (1986), a currency may be attacked even under strong fundamentals. This is due to the multiplicity of equilibria and self-fulfilling nature of attacks. If everyone believes there will be an successful attack, everyone attack, making it too costly for the central bank to defend the currency even with strong fundamentals. Hence, the initial belief is confirmed in the attack. These kind of models cannot, however, explain the timing of the attack. Morris and Shin (1998) show that the multiplicity of equilibria is due to common knowledge of the fundamentals, and that only adding a small amount of noise to the agents' signal on fundamentals result in a unique equilibrium where the timing of the attack can be determined. Corsetti et al. (2004) extends this model by introducing a single large trader that might have superior information and may choose to move early. The large player can signal his information to the small players by moving early. However, Tabellini (1994) and IMF (1998), argue, in retrospect of the ERM- and Asia-crises respectively, that large players move in the rear in currency crises because they benefit from higher interest rate differentials. Our model address this possibility.

By speculative attack we mean events where speculators take positions in the belief that monetary authorities will change the exchange rate regime in the near future. Implicit is the calculation that a policy shift will imply a change in the currency rate.[1] We study three cases of speculative pressure on the Norwegian krone (NOK): The attack during the ERM-crisis in December 1992; the attack in January 1997; and the attack after the Russian moratorium in August 1998. For this latter crisis we can also compare with Sweden which also experienced a speculative pressure on their currency. In 1992 Norway had a fixed exchange rate, while the the exchange rate was a managed float in 1997 and 1998. Sweden had officially a floating exchange rate regime in 1998, but had intervened on several occasion since the ERM-crisis in 1992–93.

For Norway we have weekly data on currency trading by Norwegian banks with Norwegian customers and Foreigners. The data differentiates between spot and forward trading and covers more than 90% of all trading in NOK.[2] Anecdotal evidence from the Norwegian market suggests that the foreign investors are leveraged institutions, or "large players", while locals can be seen as "small players". This seems particularly reasonable for periods of speculative pressure where foreigners can raise more funds than locals. In Sweden several banks, assigned as "primary dealers", report daily their buying and selling of spot and forward against locals and foreigners.

The combination of long enough time series on trading to cover a number of relevant episodes, and information on disaggregated currency flows, make our data set unique. To our knowledge only few papers exist on the topic of the role of large players. Wei and Kim (1997) study the importance of large players using the Treasury Bulletin reports. They find that trading of large players add to the volatility of exchange rates, and argue that hedge funds act like "noise traders" in the Korean market. Corsetti, Pesenti and Roubini (2002) use the same data, and compile more informal information about a number of speculative events. They find support for the role of large players and some indications of the presence of asymmetric information. Cai, Cheung, Lee and Melvin (2001) also use the Treasury Bulletin data and find that trading of large players contribute to volatility during the unwinding of the yen-carry trade in 1998.

Unlike the studies above, we have information on net positions of *both* large and small players in the periods around a speculative attack. Further, while other studies have based their findings on the correlation between the returns of highly leveraged institutions and various currencies, without any actual knowledge of

[1] See e.g. Calvo and Reinhart (2002) who argue that even if a country officially adopts a "flexible" exchange rate, they often tend to limit the fluctuations of the exchange rate.

[2] Some parts of these data are previously studied by Rime (2000).

the exact exposure the respective funds have in a particular currency, we can observe almost the total market for the currencies under investigation. Furthermore, while the former studies have focused on the Asian markets we focus on European economies. This adds a new dimension to the empirical findings in this field.

We believe our study contributes to a better understanding of the actual dynamics of a speculative attack — at least for a small, open economy with a developed and liberalized market for foreign exchange. Our results suggest that the behavior of foreign and local players differ before and during speculative attacks. Informational herding does not seem to be important. Rather, the behavior of local investors is more in line with the hypothesis of Tabellini and IMF. Locals move in advance of the attack, while foreigners seem to wait in order to reap the interest rate benefit prior to the attack. This might indicate that small, local, players have higher costs of speculation. This higher cost can be due to less liquid portfolios, as in Tabellini, less ability to move quickly, closer relationship to local public, or higher risk aversion.

In section 2 we present the model and discuss some empirical implications. Section 3 contains a description of our data and the institutional framework of the exchange rate regime. Section 4 describes the empirical methodology and our results. In the end we conclude.

2 The Model

Corsetti et al. (2004) (henceforth CDMS) analyze a model with a large trader and a continuum of small traders. In their analysis of sequential trading they only consider the alternative where the large trader speculates first, so as to create a signal affecting the behavior of the small agents. As mentioned by CDMS, however, there is empirical evidence indicating that large traders are in the rear, rather than at the front, in speculative attacks. Here we extend the theoretical framework of CDMS by allowing the large trader both to speculate early, so as to affect the behavior of the small traders, and to speculate at a later stage. Thus, the timing decision of the large trader is endogenous.

Consider an economy where the central bank aims at keeping the exchange rate within a certain interval, either a well defined, publicly known, narrow target zone, or a less explicit "dirty float" policy. There is a single "large" trader, and a continuum of "small" traders indexed to $[0, 1]$. The traders may attack the currency by short selling the currency, i.e. borrow domestic currency and sell it for dollars. The small traders taken together have a combined limit to short selling the domestic currency normalized to 1. They decide independently and simultaneously whether or not to attack the currency. If they attack there is a cost $t > 0$ to engaging in short selling. This cost can be interpreted as trading costs and the interest differential between the domestic currency and dollars. The costs are normalized so that the payoff to a successful attack on the currency, leading to a devaluation/depreciation of the currency, is given by 1, and the payoff from refraining from attack is 0. Thus, the net payoff for small players of a successful attack on the currency is $1 - t$, while the payoff to an unsuccessful attack is $-t$.

The large trader has access to a large line of credit in the domestic currency, enabling him to take a short position up to the limit of $Z > 0$. In contrast to CDMS, however, we assume a different action set and cost structure for the large trader. The large trader may trade at two different points in time, before and after the small traders. Short selling before the action of the small traders involves the cost t. Let S denote the size of any early short-selling of the large trader, where $Z \geqslant S \geqslant 0$. However, if a massive speculative attack ensures that it is clear that a devaluation will take place, the large trader has the opportunity to increase the speculative attack by using the rest of his credit at a later stage. This assumption is meant to capture the notion that larger traders have better access to rapid information, and may react quicker in the market. Speculating at a late stage involves two advantages. First, there is less uncertainty as to the outcome of the attack, as there is no uncertainty as to the behavior of the smaller traders. Second, the cost is smaller, as the costs associated with the interest rate differentials are incurred for a shorter period. To simplify the analysis, we shall assume that an attack by the large trader at this stage involves no uncertainty and no costs, implying a total gain to the large trader of $Z - tS$ if a devaluation takes place.

Following CDMS, we let the strength of the economic fundamentals of the exchange rate regime be indexed by a random variable θ. This can be interpreted as a reduced form of the central bank reaction function, indicating how much reserves they are willing to use in the defense. If the fundamentals support the current regime, i.e. are strong, the central bank is willing to use more reserves in the defense. The strength of the speculative attack is measured by the amount used by the traders attacking the currency. Whether the current exchange rate regime is viable depends on the strength of the economic fundamentals relative to the strength of the speculative attack. To keep the analysis simple, we assume that the large trader only gets access to the credit allowing him to speculate without any cost at the late stage if it is already clear that the exchange rate falls.[3] Let ℓ denote the mass of small traders that speculate. Then the exchange will fall if and only if

$$\ell + S \geqslant \theta. \tag{1}$$

If $\theta < 0$ the exchange rate will depreciate irrespective of whether a speculative attack takes place.

2.1 Information

The small traders observe a private signal that yields information about the fundamentals as well as the amount of speculation of the larger trader. A typical small trader i observes

$$x_i = \theta - S + \sigma\varepsilon_i, \tag{2}$$

where $\sigma > 0$ is a scaling-constant to the variance of the signal x. The individual specific noise ε_i is distributed according to a smooth symmetric and single-peaked density $f(\cdot)$ with mean zero, and $F(\cdot)$ as the associated c.d.f. The noise ε_i is assumed to be i.i.d. across traders. Note that the small traders cannot distinguish the information they obtain about the fundamentals from the information about the speculation of the larger trader; they only observe a noisy signal of the difference between the two. This assumption simplifies the analysis considerably. It also captures an element of realism, as small traders in reality cannot verifiably observe large traders moves in the FX market since there is no disclosure requirements in FX markets.

The larger trader observes

$$y = \theta + \tau\eta, \tag{3}$$

where $\tau > 0$ is a scaling-constant to the variance of the signal, and the random term η is distributed according to a smooth symmetric and single-peaked density $g(\cdot)$ with mean zero. To obtain explicit solutions, we assume further that $g(\cdot)$ is strictly increasing for all negative arguments, and strictly decreasing for all positive arguments. $G(\cdot)$ is the associated c.d.f.

[3] A possible justification for this assumption is that if creditors do not see that the first attack succeeds, they will not accept the risk involved in extending the credit.

2.2 Analysis

We first consider the action of the small traders, given the prior decision of the large trader. We then consider the decision of the large trader whether to initiate an early attack.

Following CDMS, we will assume that the small traders follow trigger strategies in which traders attack the currency if the signal falls below a critical value x^*.[4] As in the analysis of CDMS, there is a unique equilibrium which can be characterized by two critical values $(\theta - S)^*$ and x^*, where the former captures that the currency will always collapse if the difference between the fundamental θ and the early speculation of the large trader S is below the critical value, while the latter is the critical value in the trigger strategy of the small traders.

These critical values can be derived in the same way as in the analysis of the benchmark case in section 2.2.1 of CDMS. Given the trigger strategy, and that the true state is $\theta - S$, the probability that a small trader i will attack the currency is identical to the probability that the trader's signal is $x_i \leqslant x^*$, i.e.

$$\begin{aligned} \text{prob}\,[x_i \leqslant x^* | \theta - S] &= \text{prob}\,[\theta - S + \sigma\varepsilon_i \leqslant x^*] \\ &= \text{prob}\left[\varepsilon_i \leqslant \frac{x^* - (\theta - S)}{\sigma}\right] = F\left(\frac{x^* - (\theta - S)}{\sigma}\right). \end{aligned}$$

Since there is a continuum of small traders, and their noise terms are independent, there is no aggregate uncertainty as to the behavior of the small agents, so that the mass of small players attacking, ℓ, is equal to this probability. As $F(.)$ is strictly increasing, it is apparent that the incidence of the speculative attack is greater, the weaker the strength of the economic fundamentals, less the early speculation of the large trader $(\theta - S)$.

A speculative attack will be successful if the mass of small traders that speculate exceeds the strength of the economic fundamentals, less the early speculation of the large trader, i.e. if

$$F\left(\frac{x^* - (\theta - S)}{\sigma}\right) \geqslant \theta - S.$$

Thus, the critical value $(\theta - S)^*$, for which the mass of small traders who attack

[4] CDMS show that there are no other equilibria in more complex strategies.

is just sufficient to cause a devaluation, is given by the equality

$$F\left(\frac{x^* - (\theta - S)^*}{\sigma}\right) = (\theta - S)^*. \tag{4}$$

For lower values of $(\theta - S)$, the incidence of speculation is larger, and the strength of the fixed exchange rate lower, implying that an attack will be successful if $\theta - S \leqslant (\theta - S)^*$.

Consider then the trigger strategies of the small traders. A trader observes a signal x_i, and, given this signal, the success-probability of an attack is given by

$$\begin{aligned} &\text{prob}\,[\theta - S \leqslant (\theta - S)^* \,|x_i] = \text{prob}\,[x_i - \sigma\varepsilon_i \leqslant (\theta - S)^*] \\ &\quad = \text{prob}\left[\varepsilon_i \geqslant \frac{x_i - (\theta - S)^*}{\sigma}\right] = 1 - F\left(\frac{x_i - (\theta - S)^*}{\sigma}\right) = F\left(\frac{(\theta - S)^* - x_i}{\sigma}\right), \end{aligned}$$

where the last equality follow from the symmetry of $f\,(.)$, $F\,(\nu) = 1 - F\,(-\nu)$. The expected payoff of attacking the currency for trader i, per unit of speculation, is thus

$$\begin{aligned} (1-t)F\left(\frac{(\theta - S)^* - x_i}{\sigma}\right) - t\left(1 - F\left(\frac{(\theta - S)^* - x_i}{\sigma}\right)\right) \\ = F\left(\frac{(\theta - S)^* - x_i}{\sigma}\right) - t. \end{aligned}$$

For the marginal trader, the expected payoff of attacking the currency must be zero, i.e. the optimal cutoff x^* in the trigger strategy is given by

$$F\left(\frac{(\theta - S)^* - x^*}{\sigma}\right) = t. \tag{5}$$

To solve for the equilibrium, we rearrange (5) to obtain $(\theta - S)^* = x^* + \sigma F^{-1}(t)$. Substituting into (4), we get

$$\begin{aligned} (\theta - S)^* &= F\left(\frac{x^* - (x^* + \sigma F^{-1}\,(t))}{\sigma}\right), \text{ or} \\ (\theta - S)^* &= F\left(-F^{-1}\,(t)\right) \\ &= 1 - F\left(F^{-1}\,(t)\right) = 1 - t. \end{aligned}$$

Thus, the critical values are

$$(\theta - S)^* = 1 - t, \text{ and} \tag{6a}$$

$$x^* = 1 - t - \sigma F^{-1}(t). \tag{6b}$$

These critical values corresponding to the critical values in CDMS, the only novelty being the addition of the early speculation of the large trader S.

Before proceeding, let us briefly describe the economic outcome so far. As noted above, there is no aggregate uncertainty as to the behavior of the small traders. All traders observing a signal $x_i \leqslant x^*$ will attack. If $\theta - S \leqslant (\theta - S)^*$, the speculative attack will be successful. If $t < \frac{1}{2}$, then $F^{-1}(t) < 0$ (recall that as f has mean 0, so $F^{-1}\left(\frac{1}{2}\right) = 0$), so that $x^* > \theta - S$. Thus, in this case a small trader will attack even if he observes a signal $x_i \in (\theta - S,\ x^*)$, reflecting that the gain from a successful attack is greater than the loss from an unsuccessful one, so from equation (5) we see that the small trader will accept a probability of success below $\frac{1}{2}$.

We then consider the decision of the large trader of whether to speculate at an early stage, and if so, by how much. From (6) a devaluation will take place if the fundamental $\theta \leqslant \theta^* \equiv 1 - t + S$, and this will yield the opportunity to a profit from late speculation of Z.

The expected payoff by attacking in the amount $S \geqslant 0$ at an early stage is

$$E\pi = Z \cdot \text{prob}\left[\theta \leqslant 1 - t + S | y\right] - tS = Z \cdot G\left(\frac{1 - t + S - y}{\tau}\right) - tS,$$

where we again use the symmetry of the distribution.

The first order condition for an interior solution S^* is

$$\frac{\partial E\pi}{\partial S} = Z \cdot g\left(\frac{1 - t + S^* - y}{\tau}\right)\frac{1}{\tau} - t = 0. \tag{7}$$

Note first that if $Zg(0)\frac{1}{\tau} - t < 0$ (which is equivalent to $g(0) < \frac{\tau t}{Z}$), then it is never optimal to speculate early, as this implies that $\frac{\partial E\pi}{\partial S} < 0$ for all y and S (recall that the density $g(.)$ has its maximum for the argument zero). The intuition is straightforward: if the gain from a successful speculative attack (Z) is too small relative to the cost of speculation (t) and the effect of attempts to induce a speculative attack ($g(.)$ and τ), then it will never be profitable to try to induce a speculative attack. Or, if the "large" player is not particularly larger than the small he will not try to induce the small to speculate by early trading. In the sequel, we shall assume that $g(0) > \frac{\tau t}{Z}$, implying that it will be profitable to induce a speculative attack under some circumstances, as will be discussed below.

The second order condition for an interior solution is

$$\frac{\partial^2 E\pi}{\partial S^2} = Z \cdot g'\left(\frac{1-t+S-y}{\tau}\right)\frac{1}{\tau^2} < 0.$$

From the second order condition if follows that the optimal S^* must satisfy $\frac{1-t+S-y}{\tau} > 0$, so that $g'(.) < 0$.[5]

Restricting attention to the interval $\frac{1-t+S-y}{\tau} > 0$, so that $g'(.) < 0$, and hence the inverse of $g(.)$ is defined, we can solve (7) for the optimal S:

$$\frac{1-t+S^*-y}{\tau} = g^{-1}\left(\frac{\tau t}{Z}\right), \text{ or}$$

$$S^* = y - (1-t) + \tau g^{-1}\left(\frac{\tau t}{Z}\right). \tag{8}$$

Let y^L be the value of y for which the optimal early speculation S^* is zero, i.e.

$$y^L = 1 - t - \tau g^{-1}\left(\frac{\tau t}{Z}\right).$$

Proposition 1 *Assume that* $g(0) > \frac{\tau t}{Z}$. *Then there exist critical values* y^H *and* y^L *such that if the signal of the large trader* y *is below or above these critical values,* $y \leqslant y^L$ *or* $y \geqslant y^H$*, then the optimal strategy is not to speculate early, i.e. set* $S = 0$*. If* $y \in (y^L, y^H)$*, the optimal strategy is to speculate early, setting* $S = S^* > 0$*, where* S^* *is given by (8). A marginal change in the speculation costs* t *has an ambigious effect on the optimal early speculation by the large,* S^**.*

The proof is in the appendix. The intuition behind the proposition is the following. If the signal of the large trader y is low (below y^L), reflecting that the fundamentals θ is low, the large trader will view a devaluation as so likely that he will not find it profitable to incur the costs by early speculation, even if this would increase the probability of a devaluation. Nor will the large trader find it profitable to speculate early if the signal of the large trader y is high (above y^H), reflecting that the fundamentals θ is high, as in this case it will be too costly

[5] For $\frac{1-t+S-y}{\tau} < 0$, we have $g'(.) > 0$ implying that $\frac{\partial^2 E\pi}{\partial S^2} > 0$, so that a solution to (7) would be a local profit minimum.

to raise the probability of a devaluation. However, for interior values of y, the gain from increasing the probability of a successful speculative attack by an early speculation of the large trader is sufficiently large to outweigh the costs, and the large trader will indeed speculate early. Note that the optimal early speculation S^* is strictly increasing in the interval (y^L, y^H), starting at zero for y^L and reaching its maximum for y^H, for then to fall to zero again for $y \geqslant y^H$. The ambiguous effect of an increase in the speculation costs on the amount of early speculation reflects two opposing effects. On the one hand, higher speculation costs will reduce speculation by small traders, inducing the large trader to do more early speculation himself (cf. equation (8)). On the other hand, higher speculation costs make it more costly to speculate early, which has a dampening effect on early speculation.

3 Data and description of crises

3.1 Trading data

Norges Bank and Sveriges Riksbank collect data from market making banks on net spot and forward transactions with different counterparties. From Norges Bank we have weekly observations on Norwegian market making banks' trading with foreigners, locals,[6] and the central bank. Foreign participants are typically dominated by financial investors, especially in periods of turbulence. In the data set from Sveriges Riksbank we have daily observations on market making banks' (both Swedish and foreign) trading with non-market making foreign banks and with non-bank customers. The first group represents financial investors (see Bjønnes, Rime and Solheim, 2004). The Norwegian data distinguish between spot and forward. The Swedish data also contain swap and option volumes in addition to purchases and sales of spot and forward contracts. For Norway we have observations from 1991, while the Swedish data set start in 1993.

The two data set will be closer presented in the discussion of the three crises below.

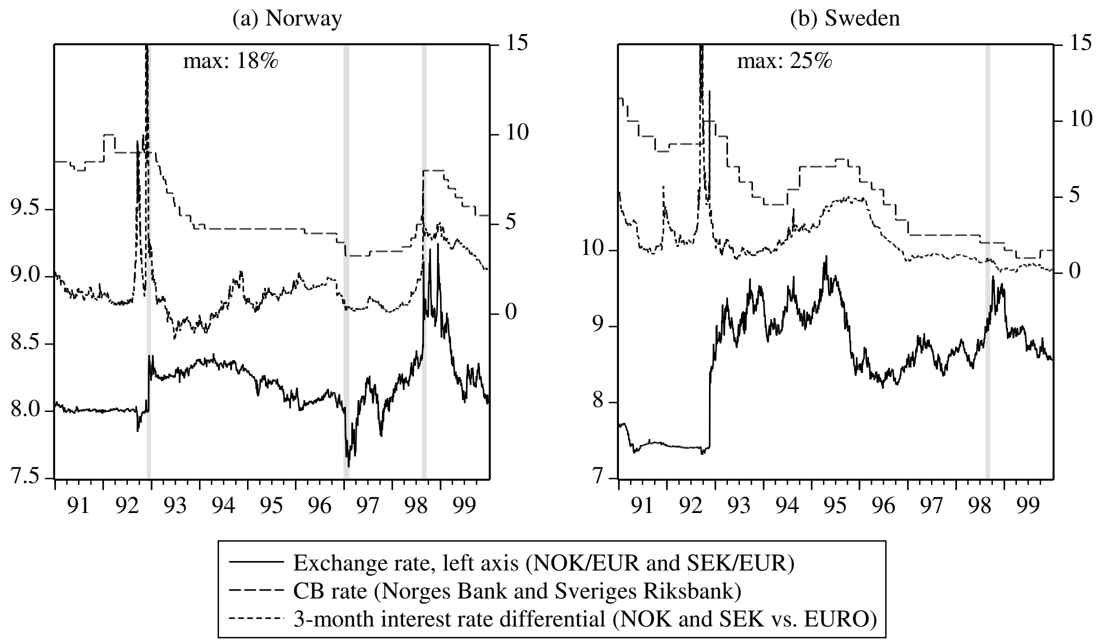
3.2 Three crisis periods in Scandinavia

In this section we give a brief overview of the three crisis periods we will empirically analyze. The three periods are (i) the ERM-crisis and the devaluation of the

[6] Foreigner and local are defined by their address.

Norwegian krone in December 1992; (ii) the appreciation of the Norwegian krone in January 1997; and (iii) the crisis in both Norway and Sweden following the Russian moratorium in August 1998. Fig. 1 shows the NOK/EUR and SEK/EUR exchange rates, together with the Norwegian folio rate and the Swedish discount rate and the 3-month interest differential toward Germany for the two countries, from the beginning of 1990 until the end of 2000.

Figure 1: Exchange rate, Central bank rate, and 3-month interest differential: Norway and Sweden



Exchange rate measure along the left axis, and central bank rate and interest differential along the right axis. Shaded areas indicate the crises.

The key dates for the attacks can be identified e.g. from the financial press. In addition we have created the usual "crisis index" used to identify events with special pressure on the exchange rate (see e.g. Eichengreen, Rose and Wyplosz, 1995, for a description). The crisis index, which take into account that a speculative pressure may materialize through interest rate changes instead of exchange rate changes, also identifies these three periods. The index identifies several single events, but these three periods are the only clusters of events.[7]

3.2.1 The erm-crisis: 1992

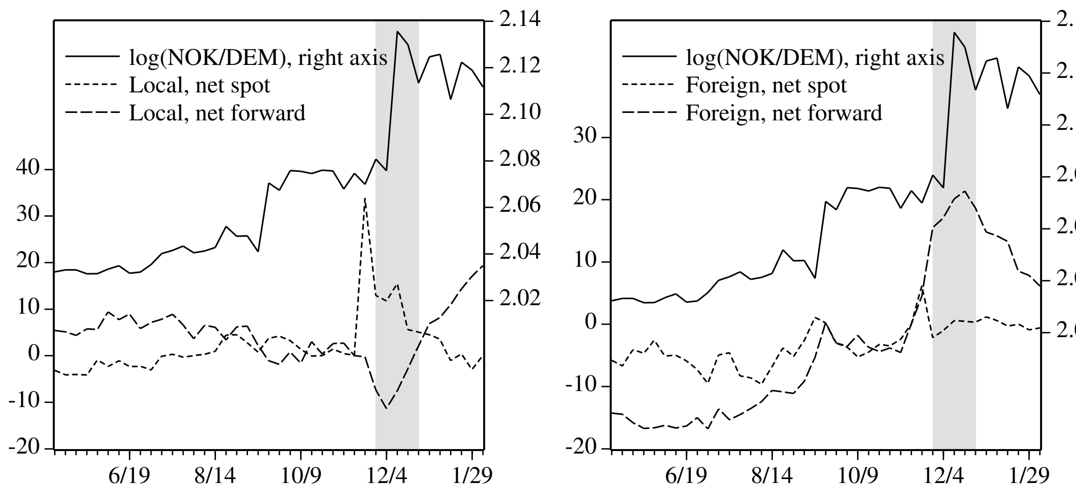
The 1992-event has the features of a "traditional" currency crisis. Prior to 1992 both Norway and Sweden had fixed their exchange rates to the ECU, with a fluc-

[7]The results for the crisis index are available upon request.

tuation band of ± 2.5% and ± 1.5% respectively. From Fig. 1 we see that during 1991 and until October 1992 the Norwegian exchange rate was stable around a level of 7.65. In August first Finland and Italy, and later Great Britain, were forced to abandon their fixed pegs. Sweden withstood an attack in September, but chose to devalue in late November after increasing interest rates to 500%. Under the speculative pressure during the fall of 1992 Norges Bank repeatedly increased their borrowing rate to reduce capital outflow. At December 10, 1992, the Norges Bank was forced to abandon the fixed ECU-rate. The exchange rate stabilized in the interval between 8.3 and 8.4, implying a change of about 10% from middle rate to middle rate.

In Fig. 2 we see the levels of net positions in spot and forward for locals and foreigners in the period from May 1992 to January 1993. One of the most striking features of this figure might be how stable these positions are throughout the first part of 1992. The only position that reveal a change is foreign forward. Here we see a trend out of NOK-holding from early August 1992. The holdings do however stabilize in October 1992. First in November 1992 does evidence of speculative activity occur in our series. It takes two forms: locals sell NOK spot and foreigners sell NOK forward. This is as one should expect. Locals have a larger part of their portfolio in NOK, and should therefore be able to sell NOK spot. Foreigners hold presumably a more limited amount spot. To profit on the expected devaluation they sell NOK forward.

Figure 2: The exchange rate and the level of net positions: Norway during the ERM-crises.



A negative number indicates a net holding of NOK. Exchange rates measured along the right axis and flows on the left axis.

3.2.2 The Norwegian crisis: 1997

In the aftermath of the ERM-crisis Norway and Sweden chose different monetary policy regimes. Sweden adopted a formal inflation target of 2% in 1993. Norway, on the other hand, chose a managed float regime. Norges Bank had an obligation to stabilize the exchange rate, but only in a medium term sense. Extreme measures to hold the exchange rate within bounds in the short term were not to be used.[8]

In January 1997 there was a particular speculation inducing an appreciation of the Norway krone. The cost of a DEM in NOK fell with more than 5% over a period of 14 days with the largest changes on Jan. 8th – 10th, while the SEK/DEM was largely unaffected. Pressure against NOK had been building for some time prior to this. A number of newspaper reports referred to the role of foreigners speculating in a Norwegian appreciation during the fall of 1996. For instance, on November 5 1996, the leading business newspaper in Norway (Dagens Næringsliv) reports that foreign analysts "believe in stronger NOK".[9] Already on the next day, Norges Bank lowered the folio rate. According to newspapers, Kjell Storvik (the governor of the bank) hoped that this would reduce the interest for NOK among foreign investors.[10] November 29, 1996, the Dagens Næringsliv states that

> [f]oreigners have again thrown themselves over the Norwegian krone. [...] People in the market [...] believe that the strengthening is a result of foreign investors now believing NOK is so cheap that is a good buy.[11]

In Norway the events of 1997 are generally understood as "endogenous" — speculators believed that a strong Norwegian economy and emerging inflationary pressure would force the Norwegian government to change from a managed float to an inflation targeting regime. Inflation targeting would allow Norges Bank to set interest rates higher to fight inflation, with little regard to a potentially steep appreciation of the NOK. Norges Bank did in stead defend the exchange rate by decreasing the folio rate.

[8] The monetary policy regulation from May 6, 1994, stated: "... monetary policy instruments will be oriented with a view to returning the exchange rate over time to its initial range. No fluctuation margins are established, nor is there an appurtenant obligation on Norges Bank to intervene in the foreign exchange market." Norway officially introduced an inflation target of 2.5% in March 2001.

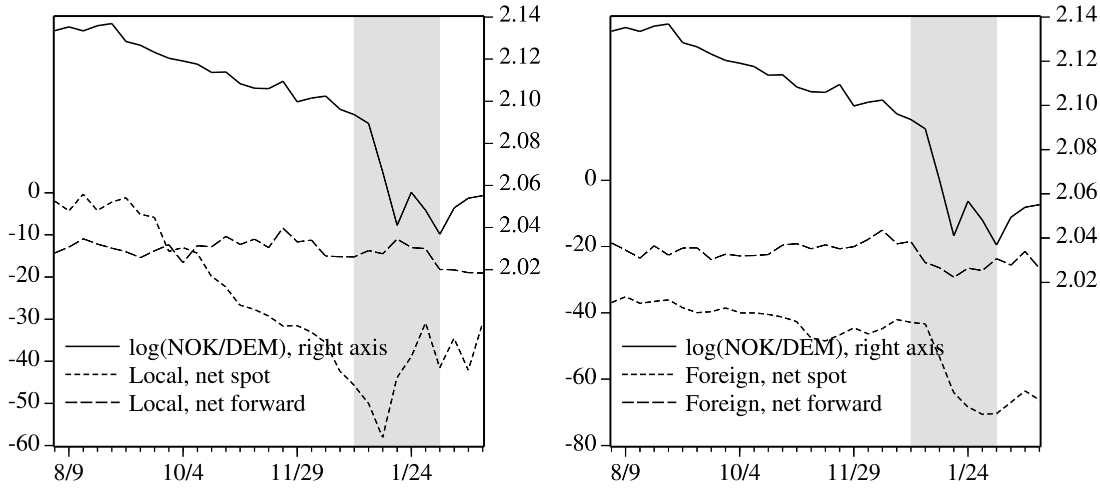
[9] Mathiassen (1996).

[10] Dagens Næringsliv (1996).

[11] Haug (1996).

Fig. 3 shows the NOK/DEM exchange rate and the level of net positions during the period from August 1996 to February 1997. First, note that there is no movement in the forward positions over this period. Second, we see that the exchange rate was trending down from early September 1996. In the period from September to December locals accumulate spot foreign currency positions as the exchange rate is appreciating. Foreigners do not change their net positions. During the speculative attack in the first weeks of 1997, the central dates were January 6-7 1997, foreigners are buying NOK spot. At this time locals were selling NOK spot.

Figure 3: The exchange rate and the level of net positions: The Norwegian 1997-crises.



A negative number indicates a net holding of NOK. Exchange rates measured along the right axis and flows on the left axis.

3.2.3 The Russian moratorium crisis: August 1998

The 1998-crisis in Norway and Sweden took place at the same time as Russia declared a debt moratorium, which was the starting point of a period with substantial international financial turbulence and uncertainty. Russia experienced a boom during the mid-1990's, not least due to high oil prices. However, in June 1998 Russia began to experience balance of payment problems as oil prices had fallen substantially through the year.[12] Russia turned to negotiations with the IMF and international creditors, and, after severe problems, an agreement was reached

[12]Oil prices fell from USD 17 at the beginning of 1998 to an average price of USD 12.50 in the period June-October 1998.

on the evening of Sunday, July 12. In the ten days prior to this agreement the central bank of Russia had sold USD 1.6 billion in attempts to stabilize the exchange rate. During August the crisis reemerged, and on August 17 the Russian president Boris Jeltsin announced a reform package including a possible devaluation of the rouble. The result was a meltdown of international confidence. On August 24 Russia declared a moratorium on all debt payments. This event triggered massive international uncertainty. Investors withdrew money from small currencies, including the NOK and SEK, and countries with a high share of raw material exports where especially hard hit. In addition the turbulence in the South-East Asia was not over.

In Norway the largest changes in the exchange rate was on the 24th and the days immediately following. Market participants had for some time expected a change in the monetary regime, from managed float to inflation targeting. During the spring of 1998 Norway experienced a slowdown in growth, and many argued for monetary and fiscal stimulus in order to spur growth.[13] A change to inflation targeting was expected to have resulted in lower short-term interest rates in order to spur growth and thus a weaker currency.

The reaction functions of Norges Bank and Sveriges Riksbank are partly revealed when we look at Fig. 1. We see that while Norges Bank increased the deposit rate as the NOK/DEM depreciated in July and August, Sveriges Riksbank did not adjust its deposit rate in response to changes in the exchange rate during this period. This is a clear indication of two very different monetary policy regimes.

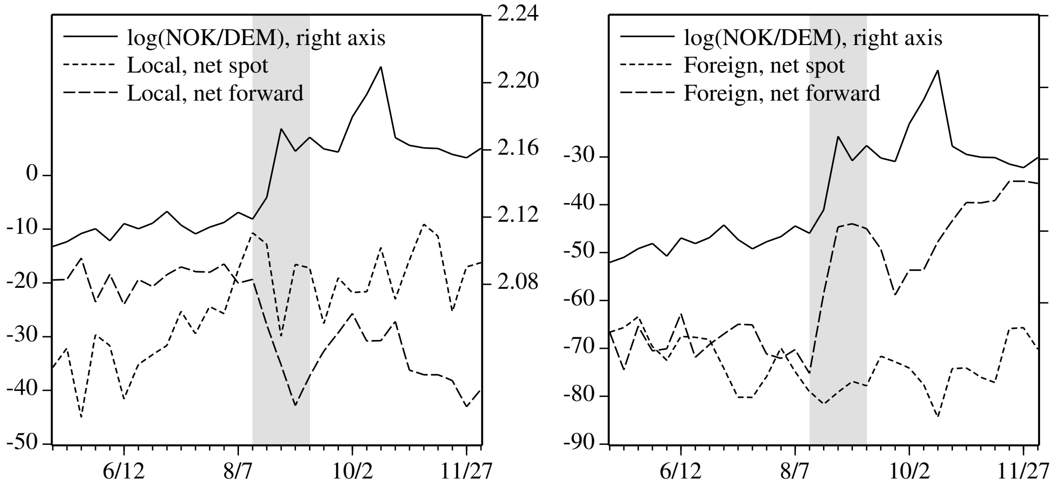
Figs. 5(a) and 5(b) shows the NOK/DEM and SEK/DEM exchange rate and the level of net positions during the period from May 1996 to December 1998. Again we see that in Norway locals were accumulating foreign currency spot during the summer. When the foreigners attacked in August they did so in the forward market. This sale of NOK was matched by locals buying NOK forward.

4 Results

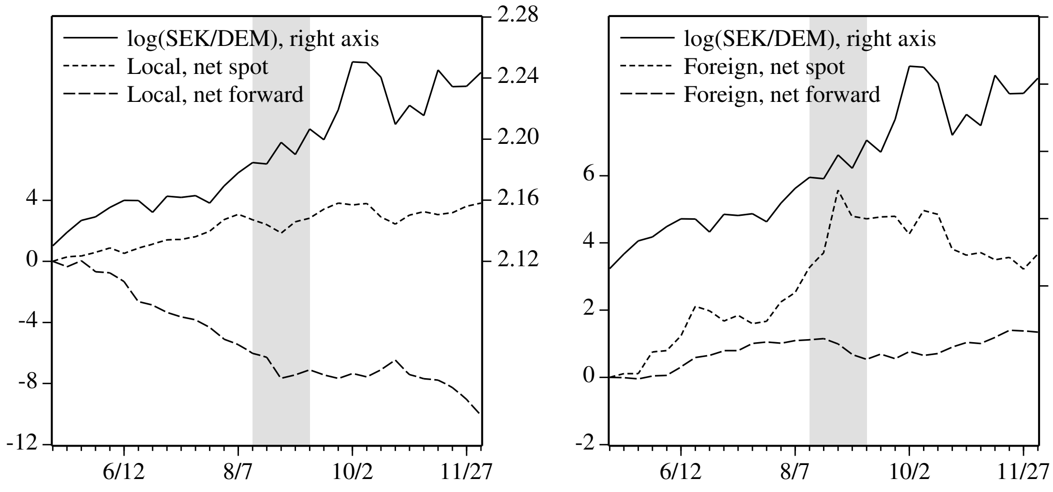
From the model presented in section 2 we have testable implications along two lines: (i) The sequence of move of the large and small players, and (ii) which players that will trigger the actual change in the exchange rate. Let us repeat: If

[13] Norway's leading indicator peaked in December 1997, and decreased during 1998.

Figure 4: The exchange rate and the level of net positions: The 1998 Russian Moratorium crisis in Norway and Sweden.



(a) Norway



(b) Sweden

A negative number indicates a net holding of NOK. Exchange rates measured along the right axis and flows on the left axis.

fundamentals are weak large players will move in the rear in order to reap interest rate benefit, while small players will move early. If fundamentals are stronger, or the interest rate benefit is small, large players may move early as well in order to induce small players to join in the attack. Only in the case that large players only speculate early will we see that only small players triggers the exchange rate change. Further we have identified four specific events, three in Norway and one in Sweden, for which we will test these hypotheses. Since foreigners can raise more funds on short notice we will treat foreigners as large players. "Size" in the model is related to funds, and not e.g. information advantages.

To test for the sequence in the speculative attacks we will use the statistical concept of Granger causality. Granger causality is not an economic definition of causality, but might give a useful distinction with regard to e.g. forecasting. On this basis we believe that Granger causality is a useful concept to distinguish between which group of players move first or last.

There is absence of Granger causality from x to y if an estimation of a variable y on lagged values of y and lagged values of x are equivalent with an estimation of y on only lagged values of y. Mathematically this can be expressed as

$$y_t = \alpha_0 + \sum_{i=1}^{k} \alpha_i y_{t-i} + \sum_{i=1}^{k} \beta_i x_{t-i} + \varepsilon_t, \tag{9}$$

where the variable x *does not* Granger cause y if the joint hypothesis of $\beta_1 = \ldots = \beta_k = 0$ is not rejected.

When choosing the sample for the Granger causality test we take the crisis dates as our starting point. We end the samples as soon as there is any signs of a stabilization of the exchange rate, i.e. when the crisis is over, and then use the 30 observations prior to this. This balance the need for sufficient number of observations without mixing crisis period and calm periods.

The results from the Granger causality tests is summarized in Table 1. We choose four different formulations in order to check for robustness: pairwise Granger causality, Granger causality in three-variables VAR's where we include the flow variable used in the attack by one group, together with the two flow variables of the other group, and finally a VAR with both spot and forward flow for both groups. By conditioning on more information we can be more confident about the results.

In Table 1 the direction of causality is indicated with arrows in the first row for each crisis. In the second row we report the p-values for the two F-tests necessary.

Table 1: Granger Causality test for flows during crises

Bivar. GC is GC-tests within a bivariate VAR, Trivar. GC is GC-tests within a trivariate VAR, and All Flows refer to a VAR with all four flows included. In the foreign spec. trivariate VAR we include the foreign flow variable used for speculation and the two local flows, and vice versa in the local spec. trivariate VAR. Locals always speculate in spot, while foreigners speculate with spot in 1997 and with forward in 1992 and 1998. All VAR's use the same 30 observations as in the graphs of Fig. 1. All tests performed at the 5%-level or better. Lags chosen based on several information criteria. All tests made in the table are based on one lag. We have in addition tested for the following lags for the Norwegian crises: For.spec. 1992 with 2 lags; bivar. GC and All flows for 1997 with 4 lags; For.spec for 1997 with 2 and 3 lags; Local.spec for 1997 with 2 lags; bivar. GC and All flows for 1998 with 3 and 4 lags; For.spec for 1998 with 2 lags; Local.spec for 1998 with 3 and 4 lags. For the Swedish 1998 crisis we have tested for the following additional lags: 2.First row in each year indicates the direction of causality. The second row reports the test-statistics, while "Local in for." gives the coefficient and t-statistic on lagged local flow in the equation for foreign flow, and similar for "For in local" We use the following two-letter abbreviations for flows: First letter indicate foreigner (F) or locals (L). Second letter indicates spot (S), forward (F), or sum of spot and forward (T).

		Bivar. GC	Trivar. GC		All flows GC
			For spec.	Local spec.	
1992	GC	LS⇒FF	LS⇒FF	LS⇒FF	LS⇒FF
Nor.	p-values	0.00 / 0.19	0.00 / 0.27	0.00 / 0.48	0.00 / 0.23
	Local in for.	0.266	0.329	0.301	0.282
		(5.24)	(5.22)	(5.01)	(4.09)
	For in local	0.129	0.092	0.078	0.010
		(1.83)	(1.08)	(0.70)	(0.10)
1997	GC	LS⇒FS	LS⇒FS	LS⇒FS	LS⇒FS
Nor.	p-values	0.00 / 0.40	0.00 / 0.47	0.00 / 0.70	0.00 / 0.82
	Local in for.	0.126	0.125	0.160	0.160
		(3.00)	(2.95)	(5.01)	(4.91)
	For in local	-0.102	-0.091	-0.057	-0.036
		(0.84)	(0.71)	(0.39)	(0.23)
1998	GC	LS⇒FF	LS⇒FF	LS⇒FF	LS⇒FF
Nor.	p-values	0.00 / 0.06	0.00 / 0.06	0.00 / 0.06	0.01 / 0.07
	Local in for.	0.421	0.414	0.453	0.446
		(3.70)	(3.39)	(3.03)	(2.64)
	For in local	0.220	0.456	0.221	0.469
		(1.95)	(1.85)	(1.90)	(1.83)
1998	GC	FS⇒LS	No GC	FS⇒LS	No GC
Swe.	p-values	0.00 / 0.39		0.00 / 0.81	
	Local in for.	-0.014		0.004	
		(0.86)		(0.23)	
	For in local	0.076		0.082	
		(2.82)		(3.00)	

For example, for the Bivar. GC for 1992 we can reject that all lags of local spot flow is zero, but we cannot reject that all lags of foreign forward flow is zero, hence the conclusion that local spot Granger cause foreign forward. The other rows report the coefficient on the first lag, which is expected to be positive, and the t-statistic. "Local in for." means that we consider the coefficient of the local flow in the equation for the foreign flow.

For the three Norwegian crises we see that locals Granger cause foreigners. This is in line with the model since in all three cases interest rate differentials changed in such a way to make it more costly to speculate early.

For the Swedish 1998-crisis there is some evidence that foreigners Granger cause locals. This result is also consistent with the model since foreigners did not have a gain from waiting as Sveriges Riksbank did not increase interest rates, hence risk-adjusted gains by moving late was lower. In Sweden, no change in monetary policy was expected, indicating a higher fundamental θ, and a higher signal y. On the other hand, lower Swedish interest rates meant that speculation costs were lower, i.e. lower t. For small traders, low θ and low t have opposing effects, leaving the impact on speculation indeterminate. For large traders, however, it follows directly from (8) and the proof of the Proposition in the appendix, that, keeping the sum of the signal and the speculation costs, $y + t$, constant, an increase in speculation costs lead to less early speculation by the large trader. In other words, in the speculative attack in Sweden, where interest rates were low, we would expect more early speculation by the large trader.

The second question is to identify which group was most active during the actual crisis. To investigate this question we use the following strategy. We regress changes in the exchange rate on contemporaneous changes in flows and macro variables. Due to problems of multicollinearity we run separate regressions for locals and foreigners.

The sample is selected similarly as in the GC-analysis. We use the same observations as above, but since we also estimate flow effects outside of the actual crisis we merge these three periods. Our interest is what happens during the actual speculative attack, and we create dummies that include the week before the actual attack and the largest changes around the official date. This give us three crisis-observations for 1992 and 1998, and four for 1997. Table 2 and 3 reports the regressions for Norway and Sweden respectively.

In the regressions we include the 3-month interest rate differential against

Table 2: NOK-regressions

	dlog(NOK/DEM)			
	on Foreign flows		on Local flows	
Constant	-0.00013		0.00046	
	(-0.17)		(0.50)	
Interest rate diff	-0.00062		-0.00240	
	(-1.07)		(-3.77)	**
Oil price	-0.02894		-0.03162	
	(-1.45)		(-1.47)	
92-crises, spot	0.00839		-0.00147	
	(3.75)	**	(-1.39)	
92-crises, forward	0.00687		0.00432	
	(4.29)	**	(1.68)	
97-crises, spot	0.00226		0.00088	
	(3.31)	**	(1.10)	
97-crises, forward	0.00034		-0.00903	
	(0.23)		(-2.50)	*
98-crises, spot	0.00238		-0.00183	
	(1.15)		(-4.01)	**
98-crises, forward	0.00167		-0.00152	
	(4.44)	**	(-2.20)	*
Spot	-0.00053		0.00056	
	(-1.76)		(3.00)	**
Forward	0.00026		-0.00007	
	(0.82)		(-0.20)	
AR(1)	-0.22184		-0.06703	
	(-2.06)	*	(-0.59)	
adj.R^2	0.41		0.35	
DW	2.11		2.04	

Table 3: SEK-regressions

	dlog(SEK/DEM)			
	on Foreign flows		on Local flows	
Constant	0.0005		-0.0001	
	(1.02)		(-0.20)	
Interest rate diff.	0.0174		0.0189	
	(5.24)	**	(5.56)	**
Oil price	-0.0175		-0.0180	
	(-1.99)	*	(-2.01)	*
98-crisis, Spot	0.0033		0.0027	
	(0.66)		(0.18)	
98-crisis, Forward	-0.0078		-0.0070	
	(-0.29)		(-0.71)	
Spot	0.0079		-0.0058	
	(5.82)	**	(-4.18)	**
Forward	0.0067		-0.0037	
	(5.59)	**	(-2.70)	**
AR(1)	-0.1829		-0.1513	
	(-4.11)	**	(-3.41)	**
adj.R^2	0.14		0.12	
DW-stat.	2.00		1.99	

Germany and the log-differenced oil price as macroeconomic variables. The rows labeled "Spot" and "Forward" reports the coefficients and t-values for flows outside the actual crises, while the other rows are the effect of flow in the different crisis. For Sweden we only consider the 1998-crisis.

From the GC-analysis above we would expect that foreign forward was positive and significant in the 1992-crisis, and similar for foreign spot in the 1997-crisis, and foreign forward in the 1998-crisis in the case of Norway. We would also expect that local flow were insignificant in all three crisis in the case of Norway, and at least not positive. We expect the significant variables to be positive during the crises since agents buy foreign currency (positive flow) when speculating on a depreciation (positive change in exchange rate). From Table 2 we see that these expectations are largely borne through. In addition, the foreign spot flow is significant and positive for the 1992-crisis, and some of the local flows are significant and negative for the 1997 and 1998-crises. Negative coefficients imply that the locals are providing liquidity to the foreigners during the actual attack.

For Sweden we do not find any significant effects during the 1998-crisis. Given the evidence that foreigners Granger caused locals we would expected that at least the locals were positive and significant. To interpret this result we should remember that we only found weak evidence of Granger causality from the foreign players to the locals. Furthermore, it is only in the case where the foreigners (large players) would use all their funds in the early stage of speculation one would expect no effect from foreigner and at the same time effect from the locals. In the case where foreigners do some speculation early, and some during the attack simultaneously as the locals, one might experience problems of multicollinearity.

We see that the strength of the correlation differ somewhat between the three events. For the 1992-case we find a size effect of forward flow is 0.69% per billion NOK sold, or about 5% per 1 billion USD equivalent.[14] For the 1997-event we find the spot-effect to be about 1.6% per 1 billion USD equivalent. For the 1998-event we find the effect of forward to be approximately 1.2% per 1 billion USD equivalent. As a comparison Evans and Lyons (2002) report an effect from order flow to the USD/DEM exchange rate of about 0.5% per 1 billion USD equivalent. Since this coefficient is increasing with uncertainty we would expect that our findings should be above this number. The lower numbers for 1997 and 1998 might be due to increased liquidity, less rigid monetary regimes, and possibly that external events were more important than changes in currency position during these event.

5 Conclusion

We study the dynamics of speculative attacks. The problem of connecting currency crises to fundamentals has given room for a serious discussion of possible manipulation of exchange rates, especially by large foreign players like hedge funds and other highly leveraged institutions. To analyze this we extend the model of Corsetti et al. (2004) to allow the large players to move both in front and in the rear of small players. The model of Corsetti et al. (2004) predict that large players may move early in an attack in order to induce small players to attack. It has, however, been argued by Tabellini (1994) and IMF that large players move in the rear in currency crises because they benefit from higher interest rate differentials. In our model the large players may choose to speculate early, at the same cost as small players, or later at a lower cost. The lower cost is due to benefit of interest rate differential. The small players are not able to speculate late because in that case one must be able to move quickly in order to not be *too* late. The predictions

[14] The average NOK/USD rate over the period from 1992-2000 was 7.4.

of the model are the following: If there is no gain from speculating late the large player will speculate early. If there are gains from speculating late the strategy of the large player depends on his signal of fundamentals. If fundamentals are very weak large players will do all their speculation late as there is no gain from inducing the small players to join in the attack. If fundamentals are stronger the large players may choose to speculate early with some of their funds. Unless the large players' signal on fundamentals is so strong that they choose to do all their speculation early, the change in position of the large players will be the one that trigger the attack.

The implications of the model is then tested using data on net positions of foreigners (large) and locals (small) players in Norway for the following three speculative attacks during the 1990s: The four attacks are the ERM-attack in 1992 on the Norwegian krone; the 1997 apprectionary crisis in Norway; and the August 1998 crisis following the Russian moratorium. In the latter case we can also compare with Sweden, using similar data, which also experienced a speculative pressure but followed a different strategy than the central bank of Norway. The sequence of trading is tested with Granger causality tests, while the triggering of the attacks is tested with regression analysis. We find that local players lead the foreign players in all cases except the 1998-crisis in Sweden. This is in line with the model since the Norwegian central bank used interest rates to defend the krone in all cases, while the Swedish central bank did not change their interest rate during the depreciationary crisis in 1998. Hence, while there was a gain for the large players by holding the attack in Norway, there was no gain by waiting the attack for large players in Sweden. The regression analysis show that it was foreigners that triggered the attack in all cases. We can not condition on the signal of the players in the regressions. The fact that all attacks were successful may, however, indicate that fundamentals in Norway in all four cases were in the region where large players preferred to move in the rear.

This paper is to the best of our knowledge the first to being able to study speculative attacks with data on the positions of both large (foreign) and small (local) players.

A Proof of Proposition

We begin with a few definitions. The expected payoff given an early speculation S^* is given by

$$E\pi^* = Z \cdot G\left(\frac{1-t+S^*-y}{\tau}\right) - tS^* =$$
$$Z \cdot G\left(g^{-1}\left(\frac{\tau t}{Z}\right)\right) - t\left(y-(1-t)+\tau g^{-1}\left(\frac{\tau t}{Z}\right)\right). \quad (10)$$

The expected payoff from not speculating early, yet entering at a late stage in the amount Z (for simplicity at zero cost), is

$$E\pi^0 = Z \cdot G\left(\frac{1-t-y}{\tau}\right). \quad (11)$$

Proof. Consider first the interval $y < y^L$. In this interval we know that $\frac{\partial E\pi}{\partial S} = Z \cdot g\left(\frac{1-t+S-y}{\tau}\right)\frac{1}{\tau} - t < 0$, as it follows from the derivation above that

1. $\frac{\partial E\pi}{\partial S} = 0$ for $y = y^L$ and $S = 0$.
2. $g'(.) < 0$ for all $y < y^L$ (as $g(.)$ is strictly decreasing for all positive arguments, and $\frac{1-t-y^L}{\tau} > 0$)

It follows that in this interval the optimal early speculation is zero, $S = 0$ (as we do not allow negative speculation)

We then restrict attention to $y > y^L$. Define the difference between the profit under optimal early speculation and the profit with no early speculation $W(y) \equiv E\pi^* - E\pi^0$. Using (10) and (11), we obtain

$$W(y) = Z \cdot G\left(g^{-1}\left(\frac{\tau t}{Z}\right)\right) - t\left(y-(1-t)+\tau g^{-1}\left(\frac{\tau t}{Z}\right)\right) - Z \cdot G\left(\frac{1-t-y}{\tau}\right).$$

We have that $W(y^L) = 0$, as it is optimal to set the early speculation to zero for $y = y^L$. Furthermore, note that

$$\frac{\partial W(y^L)}{\partial y} = -t + Z \cdot g\left(\frac{1-t-y^L}{\tau}\right)\frac{1}{\tau}$$
$$= -t + Z \cdot g\left(\frac{1-t-\left(1-t-\tau g^{-1}\left(\frac{\tau t}{Z}\right)\right)}{\tau}\right)\frac{1}{\tau} = -t + Z\frac{\tau t}{Z}\frac{1}{\tau} = 0.$$

Consider first the interval for y satisfying $\frac{1-t-y^L}{\tau} > \frac{1-t-y}{\tau} \geqslant 0$. It is clear that in this interval $\frac{\partial W}{\partial y} > 0$, since $g(.)$ is strictly decreasing for positive arguments, implying that $g(.)$ is greater for smaller arguments. It follows that $W(y) > 0$ in this interval; this implies that it is profitable to speculate early in a quantity $S^* > 0$ in this interval.

Then consider all y satisfying $\frac{1-t-y}{\tau} < 0$. We have

$$\frac{\partial^2 W}{\partial y^2} = -Z \cdot g'\left(\frac{1-t-y}{\tau}\right)\frac{1}{\tau^2} < 0,$$

implying that W is strictly concave. As W clearly goes to minus infinity as y converges to infinity, there is a unique value y^H for which $W(y^H) = 0$.Thus, for $y > y^H$, then $W(y) < 0$, implying that early speculation is not profitable, i.e. set $S = 0$. However, in the interval $y \in (y^L, y^H)$, $W(y) > 0$, implying that early speculation is profitable, in the amount S^*.

To find the effect of t on S^*, we differentiate (8) to obtain

$$\frac{\partial S^*}{\partial t} = 1 + \tau \frac{dg^{-1}}{d\left(\frac{\tau t}{Z}\right)}\frac{\tau}{Z}.$$

Recall that $\frac{dg^{-1}}{d\left(\frac{\tau t}{Z}\right)}\frac{\tau}{Z} = \frac{1}{g\left(\frac{\tau t}{Z}\right)'} < 0$, implying that the sign of $\partial S^*/\partial t$.is ambiguous.

■

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